CEDAR LAKE ENHANCEMENT ASSOCIATION, INC.
Cedar Lake, Indiana

CEDAR LAKE DIAGNOSTIC FEASIBILITY STUDY

MWH
MONTGOMERY WATSON HARZA

Property of
Lake and River Enhancement Section
Division of Fish and Wildlife/IDNR
402 W. Washington Street, W-273
Indianapolis, IN 46204

April 2001

FINAL

CEDAR LAKE DIAGNOSTIC FEASIBILITY STUDY

Prepared for

Cedar Lake Enhancement Association, Inc.
Cedar Lake, Indiana

Prepared by

Harza Engineering Company, Inc.
Chicago, Illinois

April 2001

CEDAR LAKE ENHANCEMENT PROJECT

Diagnostic Feasibility Study

TABLE OF CONTENTS

Figures

Appendices

EXECUTIVE SUMMARY

The Cedar Lake Enhancement Association, Inc. (CLEA) was awarded a grant from the Indiana Department of Environmental Management to prepare a diagnostic study of nonpoint source pollution in select subwatersheds to Cedar Lake. The CLEA retained Harza Engineering Company, Inc. for this assignment. The overall objectives of the diagnostic study were to identify sources of pollution in the study areas, and to recommend land management projects and institutional reforms for more detailed feasibility study.

The Cedar Lake subwatersheds are located in Lake County, Indiana, in and around the town of Cedar Lake. For diagnosis, we divided the study area into five subwatersheds, ranging in are from 69 to 332 acres.

Water quality data were collected in all five subwatersheds. Total phosphorus concentrations in all five subwatersheds were high. Three of five subwatersheds, Condos, Old Bank Building, and North Point Marina had E. *coli* concentrations that exceeded Indiana water quality standards. Total suspended solids (TSS) concentrations were high in all subwatersheds except for the Condos. Ranges of four sampling events for the five subwatershed are tabulated below.

SUBWATERSHED WATER QUALITY INDICATORS

Site	Subwatershed	E. *coli* (cfu/100ml)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)
CL-1	North Inlet[1]	3-93	0.11-0.38	5-78
CL-2	Old Bank Building	93-150	0.04-0.22	11-140
CL-3	Golf Course	3-270	0.05-0.18	40-68
CL-4	North Point Marina	3-360	0.13-0.14	18-99
CL-5	Condo	93-270	0.09-0.10	8-13

[1] Located near the Chamber of Commerce Building.

There are no point source loadings in any of the five subwatersheds. We estimated nonpoint source pollutant loading to Cedar Lake from each of the five subwatersheds. Mean areal sediment and phosphorus loadings are tabulated below.

ANNUAL SEDIMENT YIELD

Subwatershed	Load (t/yr)	Area (ac)	Areal Sediment Loading (t/ac/y)
North Inlet	298	164	0.64
Old Bank Building	3,830	164	8.19
Golf Course	176	69	0.89
North Point Marina	4,030	332	4.12
Condo	4,814	182	9.84
Total	**13,148**	**911**	

ANNUAL PHOSPHORUS LOADINGS

Subwatershed	Load (kg/yr)	Area (ac)	Areal Sediment Loading (kg/ac/y)
North Inlet	138	164	0.84
Old Bank Building	1,770	164	10.81
Golf Course	81	69	1.18
North Point Marina	1,809	332	5.44
Condo	2,369	182	12.99
Total	**6,167**	**911**	

From these data, we ranked the subwatersheds based on their relative need for nonpoint source pollution control. The Condos, Old Bank Building, and North Point Marina inlets have the greatest areal and total loadings of sediment and phosphorus. These rankings are tabulated below. Improvements in these subwatersheds will provide the most benefit to Cedar Lake.

SUBWATERSHED RANKING FOR IMPROVEMENT

Subwatershed	Area (ac)	Sediment Ranking		Phosphorus Ranking	
		Total Loading	Areal Loading	Total Loading	Areal Loading
North Inlet	164	4	5	4	5
Old Bank Building	164	3	2	3	2
Golf Course	69	5	4	5	4
North Point Marina	332	2	3	2	3
Condo	182	1	1	1	1

Best management practices (BMPs) are restrictions, structures or practices that mitigate the adverse anthropogenic effects on runoff quality and/or quantity. For the land in the subwatersheds where corn and soybean production is the dominant use, some of the most effective BMPs include conservation tillage, conservation buffers and nutrient management. The Lake County Extension Office provides education and assistance to assist these landowners.

Fertilizer management on fields, lawns, and golf courses and decreased organic matter discharges (leaves and grass clippings) into streams will help decrease stream and lake phosphorus concentrations. Landowner could be educated through brochures and newspaper articles concerning these topics and other which protect and improve water quality.

Constructed wetlands can also be a very effective part of a BMP system. Given the high phosphorus and TSS concentrations in the Condos, Old Bank Building, and North Point Marina inlets, wetland construction should be considered. Landowner concurrence and easements will be required before more detailed siting, layout, and design can commence. We recommend that the CLEA obtain funds perform to construct wetland in these areas and follow through with design and construction as funds become available. The North Point Marina inlet should receive priority as it has the largest studied watershed and is ranked among the highest for sediment and nutrients. Additionally, more land is potentially available in this location compared with others providing for a much easier and less costly design then will be required for the Condo and Old Bank Building inlets. A design for the North Point Marina inlets should utilize the existing stream channel and topography as much as possible. This will not only minimize land requirements; but, it will also considerably lower construction costs and decrease design complexity.

Streambank stabilization can effectively improve water quality and aesthetics of the Golf Course inlet. It is suggested that vegetative bank stabilization techniques be constructed on as many lineal feet of bank as funds are available. We recommend that the CLEA seek permission and involvement of the South Shore Country Club in this endeavor.

1.0 INTRODUCTION

1.1 Background

Cedar Lake, has historically, and continues to, offer a wealth of water sport activities for seasonal and year-round residents. Cultural eutrophication has affected the uses of the lake for decades. The most obvious symptoms of eutrophication are summer algae mats, sediment plumes seen in the lake following storm events, the large accumulation of sediment on the lake bottom, and reduction in water clarity.

Previous studies have identified the Sleepy Hollow Ditch subwatershed on the west side of the lake as providing degraded water quality (Echelberger, *et al.*, 1979; Echelberger, *et al.,* 1984; Jones and Marnatti, 1991; and Harza Engineering Company, 1999a). This subwatershed is currently being addressed by construction of streambank stabilization and a wetland treatment system. A number of smaller inlets enter Cedar Lake on the north, east, and southeast sides. Limited data are available to assess the impacts of these inlets on Cedar Lake water quality. This study aimed to fill this knowledge gap.

In late 1999, Indiana Department of Environmental Management (IDEM) awarded the Cedar Lake Enhancement Association, Inc. (CLEA) a grant under Section 319 of the Clean Water Act. The grant funds were used to procure the services of Harza to perform a diagnostic feasibility study on these additional inlets and subwatersheds.

1.2 Objectives

The specific objectives of this diagnostic feasibility study were:

1. To define the water quality conditions during high and low flow events of the subwatersheds and assess their effects on trophic status of Cedar Lake,
2. To identify technical feasible measures, both projects and policies, to restore the ecological integrity and recreational value of Cedar Lake, and

3. To recommend measures from the identified alternatives to study in greater depth at the engineering feasibility level.

1.3 Scope of Study

The diagnostic feasibility study involves the following tasks:

1. Data Acquisition and Review. Existing data on Cedar Lake were collected and reviewed for use in this study.
2. Field Investigations. Water quality sampling was performed at five inlet locations during four unique flow events.
3. Assessment of Existing Conditions. A land use map and soil survey map was prepared. Non-point source phosphorus loadings from the subwatersheds were estimated.
4. Identification of Alternatives. Alternatives for water quality improvement were identified, described, and recommendations presented.
5. Public Awareness. Public awareness was promoted by three public meetings.

1.4 Acknowledgements

Harza would like to extend appreciation for the assistance given to the study team by the CLEA. Particularly valuable was the assistance and enthusiasm of the CLEA's Board and President, Mr. Robert Gross, Jr. Financing was provided by IDEM through a grand under Section 319 of the Clean Water Act.

Several individuals and agencies provided important and invaluable data and input for this study including: the Indiana Department of Natural Resources (IDNR) Lake and River Enhancement (LARE) Division, IDNR Division of Fish and Wildlife, IDNR Division of Water, IDEM, the Lake County Natural Resources Conservation Service, the Environmental Systems Application Center at the School of Public and Environmental Affairs at Indiana University, the United

States Army Corps of Engineers, the Hanover Township Assessor's Office, and the Town of Cedar Lake.

This report was written by Mr. Douglas Mulvey, the Project Engineer for this study. Also contributing were Mr. David Pott (Project Manager).

2.0 PHYSICAL DESCRIPTION OF THE STUDY AREA

2.1 Location

Cedar Lake is located in the west central section of Lake County in northwestern Indiana (Figure 1). The town of Cedar Lake is approximately 35 miles southwest of Chicago. The lake is approximately 1.5 miles east of U.S. 41 in Cedar Lake.

2.2 Lake Characteristics

Much of the available information on Cedar Lake has been gathered and published by others. Principal sources of information include Echelberger, *et al.* (1979), Echelberger, *et al.* (1984), Jones and Marnatti (1991), and Harza Engineering Company (1999a).

Cedar Lake is a 781-acre kettle lake with a maximum depth of 16 feet and a mean depth of 8.8 feet (Jones and Marnatti, 1991). Table 2-1 presents a summary of lake area according to depth.

TABLE 2-1

CEDAR LAKE DEPTH-AREA RELATIONSHIP

Depth Interval (feet)	Lake Surface Area (Acres)	Percent of Surface Area (%)
0-5	177	23
5-10	309	40
10-16	290	37
16+	5	0
Total	**781**	**100**

A dam and gaging station are located at the outlet of the lake, Cedar Creek. The structure maintains a lake level of about 693 feet mean sea level (MSL), providing for a mean storage volume of approximately 6,875 acre-feet. The mean hydraulic retention time is approximately

1.25 years. This lengthy hydraulic time has limnological significance for this lake enhancement effort:

- The lake has a high sediment trapping efficiency,
- And a high phosphorus settling rate, and
- Recovery time will also be lengthy.

The Cedar Lake shoreline is heavily developed with seasonal and year-round residences. Cedar Lake Marsh, located on the south end of the lake, is approximately 350 acres while a smaller wetland on the north end of the lake near the North Inlet is approximately 11 acres. Boating, fishing, water skiing, and swimming are popular activities on the lake (Jones and Marnatti, 1991).

2.3 Watershed Characteristics

The Cedar Lake watershed, shown in Figure 2, is part of the 3,000 square mile Kankakee USGS Cataloging Unit 07120001. The Cedar Lake watershed exclusive of the lake is 4,623 acres. The watershed drains into Cedar Lake primarily through three inlets from the south and southwest sides. Two of the inlets (Pickerel Creek and an unnamed outlet near Pine Crest Marina) drain Cedar Lake Marsh. Cedar Lake Marsh in turn drains approximately 2,050 acres or 45% of the total watershed area. The third inlet is Sleepy Hollow Ditch on the southwest side of the lake. Sleepy Hollow Ditch drains an area of approximately 1,175 acres or approximately 25% of Cedar Lake's watershed. Land use in the Cedar Lake watershed is shown in Table 2-2 (Figure 3). The watershed is approximately 50% agricultural, most notably east and south of the lake. Around the lake, the properties are mainly residential with some commercial uses in the north and northeast corners. Cedar Lake Marsh comprises most of the south and southwest part of the watershed.

TABLE 2-2

LAND USE IN THE CEDAR LAKE WATERSHED[2]
(SOURCE : INDIANA GAP DATABASE)

Land Use	Area (Acres)	Area (%)
Urban	674	12.5
Agriculture	2,654	49.1
Forested	825	15.2
Wetland	376	7.0
Water	874	16.2
Total	**5,403**	

2.4 Soils

The soils in the Cedar Lake watershed are of the Plainfield-Watseka association and are shown in Figure 4. These soils are moderately sloping to nearly level, excessively drained and somewhat poorly drained soils that formed in coarse-textured glacial outwash (USDA SCS, 1992). About 45 percent of the association is Plainsfield soils and 40 percent is Watseka soils. Plainsfield soils occur on the high part of the ridges while Watseka soils occur at the base of the ridges.

2.5 Water and Sediment Quality

Historical water and sediment quality data are available for Cedar Lake and its watershed (Echelberger, *et al.*, 1979; Echelberger, *et al.*, 1984; Jones and Marnetti, 1991; Harza, 1999a). In general, Cedar Lake has high concentrations of nutrients in water and sediment and impaired water clarity, both indicators of a eutrophic lake. Watershed measurements have indicated elevated total suspended solids (TSS) and phosphorus.

[2] Land use calculations include Cedar Lake

As a component of this study, Harza collected water quality samples from stream inlets that discharge into Cedar Lake. During three of the four rounds of sampling, samples were collected from five inlet locations (CL-1 through CL-5) (Figure 5), while during one round, samples were collected at locations CL-1 through CL-3 only. Results are presented and discussed in Section 3. Samples were collected and analyzed according to procedures and methods specified in the Quality Assurance Project Plan (Harza, 1999b).

2.6 Other Resources

The DNR Division of Nature Resources was contacted during the engineering feasibility study of Sleepy Hollow Ditch (Harza, 1999a). The Division checked the Indiana Natural Heritage Program's database and sent a letter regarding their concerns. In summary:

1. Cedar Lake Marsh is identified as a "Significant High Quality Community"
2. Horned pondweed (*Zannichellia Palustris*) has been identified as a "state endangered" species present in Cedar Lake Marsh

The United States Department of the Interior, Fish and Wildlife Service was also previously contacted. A letter was sent regarding their concerns. In summary, the Service had the following comments:

1. Cedar Lake is within the range of the federally endangered Indiana bat (*Myotis sodalis*) and the Karner blue butterfly (*Lycaeides melissa samuelis*), and the federally threatened Meads milkweed (*Asclepias meadii*).
2. All Karner blue records are from northern Lake and Porter Counties. There are no Indiana bat or Meads milkweed records from the project vicinity. Some bat habitat may exist in forested areas in the lake's watershed.
3. The German Methodist Cemetery on the west side of U.S. 41 highway contains a remnant prairie plant community.

3.0 PROBLEM IDENTIFICATION

3.1 Subwatershed Descriptions

As part of this project, Harza studied water quality of five Cedar Lake subwatersheds: North Inlet (CL-1), Old Bank Building (CL-2) and Golf Course (CL-3) (Figure 5). Additionally, Harza was asked by the Cedar Lake Enhancement Association to sample water quality at the North Point Marina (CL-4) and Condo (CL-5) inlets (Figure 5). The following is a general description of these subwatersheds.

North Inlet (CL-1)

This subwatershed drains through a small 11-acre wetland and discharges under 133rd Avenue into Cedar Lake via a 1-foot diameter stainless steel culvert. The culvert is in poor condition, effectively slowing flow though it. Vegetation is not well established in the wetland, likely because water levels fluctuate greatly with the majority of water occurring during large runoff events. The subwatershed is approximately 164 acres and it drains predominantly undeveloped wooded or residential areas (Table 3-1). Runoff originates from a hilly area (up to 60 feet higher than the wetland) east of the wetland and enters Cedar Lake through a small, defined channel. These areas are shown in Appendix A, photos 3, 4, 5, and 6.

TABLE 3-1

LAND USE IN THE NORTH INLET WATERSHED

Land Use	Area (Acres)	Area (%)
Urban	52	32
Agriculture	7	5
Forested	88	54
Wetland	12	7
Water	4	2

Old Bank Building Inlet (CL-2)

Runoff enters Cedar Lake from two 2-foot diameter concrete storm sewers near the Old Bank Building. The subwatershed is approximately 164 acres of wooded and residential areas along with sporadic commercial development (Table 3-2). The culverts are under the intersection of Morse Street and 133rd Avenue. These areas are shown in Appendix A, photos 1 and 2.

TABLE 3-2

LAND USE IN THE OLD BANK BUILDING WATERSHED

Land Use	Area (Acres)	Area (%)
Urban	18	11
Agriculture	82	50
Forested	63	39

Golf Course Inlet (CL-3)

Runoff from this watershed enters Cedar Lake on the southeast side. The channel the South Shore Country Club. Flow to Cedar Lake occurs through a culvert that is controlled by a weir. This structure is located near the intersection of 145th Avenue and Cedar Lake. Because of the weir structure and lake backwater effects, flow through the drain is very minimal. Exposed and sloughing banks are common along the drain. For these reasons, it is expected that this channel bottom contains a large amount of sediment. If the weir is ever removed, high flow through this channel will most likely scour the sediment and transport it into Cedar Lake. The watershed is approximately 69 acres draining predominantly the golf course (Table 3-3). A small wooded residential area is also located in the watershed. These areas are shown in Appendix A, photos 9, 10, and 11.

TABLE 3-3

LAND USE IN THE COUNTRY CLUB WATERSHED

Land Use	Area (Acres)	Area (%)
Urban	10	14
Agriculture[3]	38	55
Forested	21	31

North Point Marina Inlet (CL-4)

This subwatershed is located on the northwest side of Cedar Lake. Two smaller streams discharge into a larger channel that flows to Cedar Lake. Both streams flow through largely wooded areas encompassing a subwatershed of approximately 332 acres (Table 3-4). Numerous trailers, serving as summer homes, are located near this channel. This area is shown in Appendix A, photo 7.

TABLE 3-4

LAND USE IN THE NORTH POINT MARINA WATERSHED

Land Use	Area (Acres)	Area (%)
Urban	43	13
Agriculture	81	24.5
Forested	161	48
Wetland	19	6
Water	28	8.5

Condos Inlet (CL-5)

This subwatershed is located on the north end of the lake. The inlet discharges via a large (30-inch diameter) concrete pipe to a small narrow 200-foot channel, and into Cedar Lake. The 182-

[3] In actuality, although this area appears as agricultural in the land use database, it is grassland as it is the golf course. In soil loss calculations presented later, the area was assumed urban grassland instead of agricultural.

acre subwatershed is predominantly wooded (Table 3-5). This area is shown in Appendix A, photo 8.

TABLE 3-5

LAND USE IN THE CONDOS WATERSHED

Land Use	Area (Acres)	Area (%)
Urban	18	10
Agriculture	48	26
Forested	116	64

3.2 Water Quality

Three sets[4] of water quality samples were collected from the subwatersheds and analyzed by Test America, Inc. of Bartlett, Illinois for biochemical oxygen demand (BOD), nitrate, ammonia-nitrogen, total Kjeldahl nitrogen, total suspended solids (TSS), and ortho and total phosphorus. *Escherichia coli* samples were analyzed by Northland Laboratories of Northbrook, Illinois. Laboratory results are reprinted in Appendix B and summarized in Tables 3-6, 3-7, and 3-8. We were to collect two low flow and two wet weather events. Wet and dry weather samples were to be collected. The subwatersheds studied only discharge during wet weather events requiring all samples to be collected during wet weather events. Field measurements were selectively taken for water temperature, pH, dissolved oxygen, specific conductivity, and turbidity. Field Data Sheets are provided in Appendix C. Where data are available, comparisons are made to historical data collected in 1979-1982 (Table 3-9) from the North Inlet and the golf course inlet (Echelberger *et al.*, 1984).

BOD

BOD is a measurement of the dissolved oxygen used by microorganisms in the biochemical oxidation of organic matter. BOD measurements are near or below the 4 mg/L detection limit

[4] One additional round of samples will be collected and analyzed in the coming weeks. Results will be included in the Final Report.

except for a measurement of 20 mg/L taken at the golf course inlet in May 2000. For comparison, a BOD of 20 mg/L is typical for a well operated wastewater treatment plant.

Nitrogen

Nitrogen is an essential nutrient for plant growth. When discharged to the aquatic environment, these nutrients can lead to the growth of undesirable algae and aquatic life. Total nitrogen is comprised of organic nitrogen, ammonia-nitrogen, nitrite and nitrate. Nitrogen can enter the stream through stormwater runoff from lands applied with fertilizer. Nitrate concentrations ranged from <1 to 2.7 mg/L. Historically, nitrate concentrations were <0.27 mg/L (Echelberger, *et al.*, 1984). Ammonia nitrogen concentrations were <0.5 mg/L except for one sample taken in May 2000 at the North Inlet that was 2 mg/L. Historically, ammonia nitrogen concentrations were <0.76 mg/L (Echelberger, *et al.*, 1984).

TABLE 3-6

FEBRUARY 2000 WATER QUALITY DATA

Description	North Inlet	Old Bank Bldg	Golf Course
Sample	CL-1	CL-2	CL-3
Lab No	568659	568660	568661
Date	28-Feb-00	28-Feb-00	28-Feb-00
E. coli (/100 mL)	3	150	<3
BOD-5 day (mg/L)	<4	<4	<4
Ammonia N (mg/L)	<0.5	<0.5	<0.5
Nitrate N (mg/L)	1.8	1.7	1.0
ortho Phosphorus (mg/L)	0.12	0.04	0.04
Total Phosphorus (mg/L)	0.19	0.04	0.05
Total Suspended Solids (mg/L)	<5	58	46

TABLE 3-7

MARCH 2000 WATER QUALITY DATA

Description	North Inlet	Old Bank Bldg	Golf Course	North Point	Condos Inlet
Sample	CL-1	CL-2	CL-3	CL-4	CL-5
Lab No	571747	571748	571749	571750	571751
Date	20-Mar-00	20-Mar-00	20-Mar-00	20-Mar-00	20-Mar-00
E. coli (/100 mL)	70	270	130	360	270
BOD-5 day (mg/L)	<4	<4	6	<4	<4
Ammonia N (mg/L)	<0.5	<0.5	<0.5	<0.5	<0.5
Nitrate N (mg/L)	<1.0	1.5	<1.0	2.7	1.5
ortho Phosphorus (mg/L)	<0.06	0.012	0.22	0.31	0.13
Total Phosphorus (mg/L)	0.11	0.18	0.22	0.14	0.09
Total Suspended Solids (mg/L)	12	11	68	18	13

TABLE 3-8

MAY 2000 WATER QUALITY DATA

Description	North Inlet	Old Bank Bldg	Golf Course	North Point	Condos Inlet
Sample	CL-1	CL-2	CL-3	CL-4	CL-5
Lab No	579959	579960	579961	579962	579963
Date	12-May-00	12-May-00	12-May-00	12-May-00	12-May-00
E. coli (/100 mL)	93	93	460	<3	93
BOD-5 day (mg/L)	<4	6	20	<4	<4
Ammonia N (mg/L)	2	<0.5	<0.5	<0.5	<0.5
Nitrate N (mg/L)	<1	<1	<1	<1	1.1
ortho Phosphorus (mg/L)	0.07	0.05	0.02	0.07	0.06
Total Phosphorus (mg/L)	0.38	0.18	0.18	0.13	0.1
Total Suspended Solids (mg/L)	78	140	40	99	8
Water Temperature (Centigrade)	19.5	16.5	19.2	19	17.3
Sample Depth (feet)	0.5	0.1	0.5	0.33	0.5
PH	NM[5]	NM[5]	NM[5]	NM[5]	NM[5]
Dissolved Oxygen (mg/L)	1.3	7.4	5.1	8.7	6.5
Specific Conductivity (mS/cm)	1.04	1.15	0.415	1.12	3.19
Turbidity (NTU)	7	10	40	7	7

[5] NM. pH meter would not properly calibrate; therefore, values are not included.

TABLE 3-9

HISTORICAL WATER QUALITY DATA (1979-1982)
(SOURCE: ECHELBERGER, JR. *ET AL.*, 1984)

	5/11/79	5/25/79		6/22/79		7/20/79	8/16/79	4/21/82	5/20/82	6/24/82	7/20/82
Parameter	**Golf Course**	**North Inlet**	**Golf Course**	**North Inlet**	**Golf Course**	**Golf Course**	**Golf Course**	**Golf Course**	**Golf Course**	**Golf Course**	**Golf Course**
Temperature (Celsius)	22.2	15	15.5	22.5	25.5	20.5	19	10	22	18.6	27
Dissolved Oxygen (mg/L)	7.4	3.2	7.5	0.7	8.4	8.9	4.7	7.7	5	3.8	0.9
PH	8	7.1	7.2	7.2	9.5	7.7	7.2	7	7	6.9	7
Alkalinity (mg/L $CaCO_3$)	107	202	115	242	124	210	13.6				
Conductivity (umhos-cm)	370	800	330	710	370	490	410				
Reactive Phosphorus (mg/L)	0.009	0.057	0.104	0.058	0.028	0.017	0.071	0.0204	0.0095	0.0115	
Total P (mg/L)	0.206	0.253	0.165	0.626	0.202	0.13	0.305	0.142	0.448	0.204	
Ammonia (mg/L)	0.08	0.66	0.27	0.14	0.76		0.41	0.09	0.05	1.2	<0.1
Nitrate (mg/L)	0.27	0.03	0.03	0	0.08		0.08				
TKN (mg/L)	2.9	2.1	1.8	4.9	4.1	2.5	2.89	4.28	1.03	3.3	0.9
Chlorophyll (mg/m^3)	12.5	25.7	0		100						
Turbidity (NTU)	35	17	31	42	32	20	20				

TSS

TSS can lead to sediment deposits and anaerobic conditions when discharged into a aquatic environment. TSS concentration ranged from <5 to 140 mg/L, with the highest concentration (140 mg/L) measured at the Old Bank Building inlet. Additionally, the Old Bank Building inlet had the highest TSS concentration during two of three sampling events.

Ortho and Total Phosphorus

Phosphorus is another essential nutrient for plant growth. When discharged to the aquatic environment in excess, these nutrients can lead to the growth of undesirable aquatic life. Orthophosphorus (operationally defined as dissolved phosphorus) are those compounds available for biological metabolism without further breakdown. Orthophosphorus is the portion of total phosphorus that passes a 0.45-micrometer filter. A major source of orthophosphorus generation in a stream is decomposition of organic matter. Orthophosphorus has a short half-life and concentration often vary widely over a short time. Total phosphorus is a measure of both particulate and dissolved phosphorus. A mechanism by which total phosphorus enters the stream is through land-applied fertilizer. Phosphorus particles become bound to the soil, and as surface runoff carries these particles to the stream, the phosphorus tends to remain in particulate form. Orthophosphorus concentrations in this study ranged from 0.04 to 0.31 mg/L. Historically, orthophosphorus concentrations ranged from 0.0095 to 0.104 mg/L. Total phosphorus concentrations ranged from 0.04 to 0.38 mg/L, and historically ranged from 0.13 to 0.626 mg/L. Highest total phosphorus values were measured at the North inlet during two of the three sampling events.

Escherichia coli

E. *coli* are the most widely known coliform bacteria populations representative of fecal sources, including sanitary discharges. Their presence is an indication that pathogenic organisms (bacteria, viruses, protozoa, and helminthes) may also be present. Indiana's standard for recreational waters state "E. *coli* bacteria, using membrane filter (MF) count, shall not exceed on hundred twenty-five (125) colony forming units (CFU) per one hundred (100) milliliters as a geometric mean based on not less than five (5) samples equally spaced over a thirty (30) day period nor exceed two hundred thirty-five (235) colony forming units per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period" (Indiana Administrative Code 327 2-1-6). E. *coli* concentrations during this study ranged from <3 to 460 CFUs/100 mL. The 235 CFU/100 mL standard was exceeded at the Old Bank Building, North Point Marina, and Condo inlets in March 2000 and at the Golf Course inlet in May 2000.

pH

Water's hydrogen ion concentration is expressed as pH. Measurements below neutral, pH 7.0, indicate higher hydrogen ion concentrations and that the water is acidic. Conversely, pH values above 7.0 show that the water is basic. Many aquatic organisms are sensitive to fluctuations in pH, and their reproduction processes are impeded under very acidic or very basic conditions in the water. Indiana's surface water standard dictate that pH should be in the range of 6–9, and variations exceeding nine will be permitted if associated with photosynthetic activity. The pH did not calibrate properly; therefore, pH values are not included. Historically, pH ranged from 6.9 to 9.5.

Dissolved Oxygen

Dissolved oxygen (DO) is a measure of the amount of oxygen dissolved in the water column available to support aquatic life. DO levels near the saturation point indicate conditions favorable for a variety of life, while water with low DO levels is only able to support a few species. Many species suffer if DO levels fall below 3-4 mg/L. Streams absorb oxygen directly from the air and from aquatic plants undergoing photosynthesis. Supersaturated, DO concentrations (>100%) generally indicate nutrient enrichment, with photosynthesis causing the very high levels. Indiana's surface water quality standards dictate that DO levels shall average at least 5 mg/L per day and at no time should levels fall below 4 mg/L. DO ranged from 1.3 to 8.7 mg/L. The DO concentration of 1.3 mg/L was measured at the North inlet. Flow was low during this sampling period, possibly leading to this low concentration. Historically, DO ranged from 0.7 to 8.9.

Conductivity

Conductivity is the ability of water to carry an electric current and depends on the concentration of dissolved ions. It is an indirect measure of the dissolved solids in the water. Typical dissolved solids include salts, organic materials, and nutrients. Conductivity during this study ranged from 0.415 to 3.19 mS/cm. The high value of 3.19 mS/cm occurred at the Condos inlet, possibly an indicator of road salt coming from the city streets in the subwatershed.

Turbidity

Turbidity, in Nephelometric Turbidity Units (NTU), is a measure of the light-transmitting properties of water. It is used to indicate the quality of water with respect to colloidal and residual suspended matter. The measurement of turbidity is based on comparison of the intensity of light scattered by a sample as compared to the light scattered by a reference suspension. Turbidity is related to soil erosion, particulate matter from aquatic life, and suspension of bottom sediments due to wind, high flows, and/or aquatic organisms. Turbidity measured during this study ranged from 7 to 40 NTU. Historically, it ranged from 17 to 42 NTU.

3.3 Summary of Subwatershed Water Quality

We studied five subwatersheds that discharge into Cedar Lake. Streams that discharge from all five of these subwatersheds were sampled. Key indicators of stream health were judged to be E. *coli*, phosphorus, and TSS concentrations. Table 3-10 reiterates these data. High TSS concentrations are noted in all subwatersheds except for the Condos. Total phosphorus concentrations are high for all subwatersheds with the North Inlet having the highest values. E *coli* values are high for all subwatersheds with the Golf Course, North Point and Condo inlets exceeding Indiana water quality standards.

TABLE 3-10

SUBWATERSHED WATER QUALITY INDICATORS

Site	Subwatershed	E. *coli* (cfu/100ml)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)
CL-1	North Inlet	3-93	0.11-0.38	5-78
CL-2	Old Bank Building	93-150	0.04-0.18	11-140
CL-3	Golf Course	3-270	0.05-0.22	40-68
CL-4	North Point Marina	3-460	0.13-0.14	18-99
CL-5	Condos	93-270	0.09-0.10	8-13

4.0 POLLUTION SOURCES

Pollution sources are generally divided into two broad categories: point sources and nonpoint sources. Point sources are traceable to a single point of discharge into the waterway, and are usually regulated by state or federal permits (such as National Pollutant Discharge Elimination (NPDES) Permits). Municipal treatment plants and industrial discharges are examples of point source discharges to a waterbody. Nonpoint source pollution is diffuse and can be difficult to trace to any one particular site. Typically, nonpoint source pollutants are transported to the waterbody via stormwater runoff. Sediments and nutrients are common pollutants that are washed from agricultural fields, streets, or construction sites during runoff events or atmospheric deposition, although other delivery mechanisms exist. Because there are not any point source discharges in the Cedar Lake watershed, the following discussion concentrates on nonpoint sources.

4.1 Nonpoint Source Modeling Objective and Approach

The nonpoint sources of pollution to Cedar Lake are attributable to stormwater runoff from the surrounding watershed. Stormwater runoff can carry considerable sediment and nutrient loading, depending on land use, vegetative cover and other factors. The principal nonpoint sources in the study area are agricultural cropland, the golf course, and urban runoff.

To evaluate nonpoint source loadings in the study area tributary watersheds, we reviewed available techniques, selected that most applicable with available resources and applied it. USEPA's 1997 *Compendium of Tools for Watershed Assessment and TMDL Development* divides watershed models into three categories:

1. Simple methods
2. Mid-range models
3. Detailed models

The simple models typically predict annual loadings of pollutants to a waterbody, based upon empirical loading factors corresponding to watershed characteristics. Mid-range models are also typically based on empirical loading factors, but can provide greater temporal resolution (i.e., continuous simulation) and include site-specific runoff concentration data. Detailed models take a rigorous mechanistic approach to calculate nonpoint source loads, and predict pollutant accumulation and washoff rates in the surface as well as subsurface fate and transport.

To select a model for use, we considered:

- Site specific characteristics
- Management objectives
- Available resources

Site-specific features for selecting a watershed model include the constituents of interest (nutrients and solids) and the nature of land use (forest, agriculture, and to a lesser extent, urban). Available resources include field data for the sites and the time available to devote to the assessments. The effort to appropriately apply a rigorous watershed model would require several years of data collection and analysis. Because of the desire to have a management tool developed in a short time frame and with limited data, it was recognized that a high or mid-level of complexity for the watershed model would not be suitable. Simple methods were considered for the loading models.

The EPA screening procedures (Mills *et al.*, 1985) are recommended as an appropriate simple modeling approach for simulating loads from all five subwatersheds in the study area. This approach can be used to predict sediment and nutrient losses using the Universal Soil Loss Equation (USLE), runoff curve number procedure, and loading functions. Detailed calibration of the watershed model is, in fact, not necessary. Model objectives are to discriminate between tributary watershed and to identify problem areas. The relative results of modeling are more informative than the absolute values.

4.1.1 Sediment Loading Estimates

Sediment loadings to Cedar Lake were computed for each of the five subwatersheds included in this study. The EPA's Simple Method for Watershed Sediment Yield was used to sediment loadings based on rainfall, land use, and soil type within each subwatershed (Mills *et al.*, 1985). The watershed sediment yield due to surface erosion is:

$$Y = s_d \sum_k X_k A_k \qquad \text{Equation (1)}$$

where

Y = annual sediment yield (tons/year)

X_k = erosion from source area k (tons/ha)

A_k = area of source area k (ha)

s_d = watershed sediment delivery ratio

Erosion from each subwatershed was estimated using the USLE, which is an empirical equation designed to predict average annual soil loss from source areas. The relationship is as follows (Mills *et al.*, 1985):

$$X = 1.29(E)(K)(ls)(C)(P) \qquad \text{Equation (2)}$$

where

X = soil loss (t/ha)

E = rainfall/runoff erosivity index (100 m-ton-cm/ha-hr)

K = soil erodibility (t/ha per unit of E)

ls = topographic factor

C = cover/management factor

P = supporting practice factor

The erosivity term, E, is dependent upon rainfall intensity. Average annual values for the United States are presented in Mills *et al.* (1985). For the Cedar Lake watershed, the average value is 160 (100 m-ton-cm/ha-hr). Soil erodibility (or "K" values) are a function of soil texture and organic content. Soil type was identified for each subwatershed using the STATSGO database (Figure 6). For our subwatersheds of interest, the soil type at the association level is the same. The K value for this association, IN004, is 0.38.

The topographic factor, ls, is related to slope angle and slope length by the following relationship:

$$ls = (0.045x)^b (65.41 \sin^2 \theta + 4.56 \sin \theta + 0.065) \qquad \text{Equation (3)}$$

The slope angle θ is obtained from the percent slope, s, by:

$$\theta = \tan^{-1}(s/100) \qquad \text{Equation (4)}$$

Slopes and slope lengths of each soil type were taken from data provided by the Lake County NRCS. The resulting topographic factors are listed in Table 4-1.

TABLE 4-1

TOPOGRAPHIC FACTORS
(SOURCE: LAKE COUNTY NRCS)

Subwatershed	Predominant Soil Types	Estimated ls
North Inlet	Carlisle, Morley	0.50
Old Bank Building	Morley	0.85
Golf Course	Pewamo, Morley	0.42
North Point Marina	Morley	0.85
Condo	Morley	1.91

The cover/management C factor is a measure of the protection of the soil surface by plant canopy, crops, and mulches. The maximum C value is 1.0, which corresponds to no protection, while a value of 0.0 corresponds to total protection. Published C values were selected from Wischmeier and Smith (1978) based on the land use type (Table 4-2).

TABLE 4-2

C VALUES FOR VARIOUS LAND USES

Land Use	**C Value**
Urban	0
Agriculture	0.28
Grassland	0.055
Forest	0.004
Wetland	0.055
Water	0

The supporting practice factor P is a measure of the effect of traditional soil conservation practices on erosion from agricultural fields. We used a P factor of 1 in the model, indicating no conservation practices. The use of unity for the P factor is a worst-case assumption, most likely resulting in an overestimate of soil loss.

The watershed sediment delivery ratio is a measure of the attenuation of sediment through deposition and filtering as it moves from the source areas to the waterbody. EPA guidance (Mills *et al.*, 1985) suggests that the sediment delivery ratio is a function of the watershed drainage area. A figure from Mills *et al.* (1985) depicting this relationship was used to determine the sediment delivery ratio for each subwatershed. The sediment delivery ratios for the Cedar Lake subwatersheds range from 0.34 to 0.35.

With these data, the annual sediment yield for each subwatershed was calculated using Equations 1 through 4 and subwatershed land use data (Figure 3). The results are presented below (Table 4-3).

TABLE 4-3

ANNUAL SEDIMENT YIELD FOR STUDY AREA SUBWATERSHEDS

Subwatershed	Load (t/yr)	Area (ac)	Areal Sediment Loading (t/ac/y)
North Inlet	298	164	0.64
Old Bank Building	3,830	164	8.19
Golf Course	176	69	0.89
North Point Marina	4,030	332	4.12
Condo	4,814	182	9.84
Total	**13,148**	**911**	

4.1.2 Phosphorus Loading

Phosphorus loadings to Cedar Lake were also estimated for each of the five subwatersheds included the study area. The EPA's Simple Method for Watershed Particulate Phosphorus was used. This method calculates phosphorus loadings based on the sediment yield, phosphorus concentration in the soil, and the nutrient enrichment ratio (Mills *et al.*, 1985). The watershed phosphorus yield due to surface erosion is:

$$W = 0.001\, s_d \sum_k Cs_k X_k A_k \qquad \text{Equation (5)}$$

where

W = particulate phosphorus load in runoff (kg/yr)

Cs_k = concentration of phosphorus in eroded soil (sediment) (mg/kg)

X_k = soil loss (tons/ha) from source k

The concentration of chemical in eroded soil, Cs, is computed using the following relationship:

$$Cs = en\ Ci \qquad \text{Equation (6)}$$

where

en = nutrient enrichment ratio

Ci = nutrient concentration in *in situ* soil (mg/kg)

Concentrations of phosphorus in the *in situ* soil were not available from the STATSGO database or the Lake County Soil Survey. We estimated phosphorus concentration from a general map (Mills *et al.*, 1985). Lake County Indiana has a range of percent P_2O_5 as phosphorus of between 0.1 and 0.19 percent. We opted to use an intermediate value of 0.15%, or 660 mg/kg as P.

A nutrient enrichment ratio is a measure of the degree of erosion that occurs during a storm. Since an annual phosphorus load is desired, an enrichment ratio of 2.0 is suggested by Mills *et al.* (1985). Therefore, the corresponding Cs value is 1,320 mg/kg.

The Cs value is assumed to be the same for all source areas and land types, therefore Equation 5 becomes:

$$W = 1.32\, s_d \sum_k X_k A_k \qquad \text{Equation (7)}$$

Table 4-4 contains the results of these calculations for each subwatershed in the study area.

TABLE 4-4

ANNUAL PHOSPHORUS LOADINGS

Subwatershed	Load (kg/yr)	Area (ac)	Areal Sediment Loading (kg/ac/y)
North Inlet	138	164	0.84
Old Bank Building	1,770	164	10.81
Golf Course	81	69	1.18
North Point Marina	1,809	332	5.44
Condo	2,369	182	12.99
Total	**6,167**	**911**	

4.2 Summary and Conclusion

Based on the nonpoint source modeling performed as part of this project, the studied subwatersheds were ranked to determine which provide the most nonpoint source pollution. A rank of 1 indicates that that subwatershed is the biggest pollution source and therefore should be addressed first. Table 4-5 presents these rankings. The subwatershed having the largest sediment and phosphorus loadings are the Condos inlet followed by North Point Marina and the Old Bank Building inlets. The USLE model predicts these locations provide 13 times more pollutant loadings than do the North and Golf Course inlets.

TABLE 4-5

SUBWATERSHED RANKING FOR IMPROVEMENT

Subwatershed	Area (ac)	Sediment Ranking		Phosphorus Ranking	
		Total Loading	Areal Loading	Total Loading	Areal Loading
North Inlet	164	4	5	4	5
Old Bank Building	164	3	2	3	2
Golf Course	69	5	4	5	4
North Point Marina	332	2	3	2	3
Condo	182	1	1	1	1

The NPS model has predicted that the Condos, North Point Marina, and Old Bank Building inlets have the highest sediment and phosphorus total and areal loads. In order to compare measured and modeled water quality values, measured water quality values (Table 3-10) have been converted to loads by multiplying the maximum measured concentration by the source area and predicted flow of a 1-inch storm event. Results are provided in Table 4-6.

TABLE 4-6

ESTIMATED LOADS CALCULATED FROM MEASURED WATER QUALITY

Subwatershed	Area (ac)	Flow (acre-feet)[6]	Max TSS Concentration (mg/L)	Max TP Concentration (mg/L)	Max TSS Load (kg)	Max TP Load (kg)
North Inlet	164	0.6	78	0.38	60	0.29
Old Bank Building	164	1.1	140	0.18	190	0.24
Golf Course	69	0.5	68	0.22	44	0.14
North Point Marina	332	1.6	99	0.14	198	0.28
Condos	182	0.7	13	0.10	11	0.09

The results were ranked with the same method used in Table 4-5. Results are presented in Table 4-7.

TABLE 4-7

SUBWATERSHED RANKING FOR IMPROVEMENT[7]

Subwatershed	Area (ac)	Rank (Sediment Loading)	Rank (Phosphorus Loading)
North Inlet	164	3	1
Old Bank Building	164	2	3
Golf Course	69	4	4
North Point Marina	332	1	2
Condo	182	5	5

It is noted that three discrete samples are not necessarily a good indicator of water quality. Multiple samples over many seasons and flow regimes provide greater accuracy. Our NPS model and loading estimates based on actual measured concentrations agree that the Old Bank Building

[6] Flow estimate for a 1-year, 24-hour storm.
[7] Rankings are based on a 1-inch storm and maximum value of measured water quality.

and the North Point Marina inlets are providing degraded water quality. Therefore, we have assumed the results predicted by the NPS model are reasonable and recommendations will be made using these results.

5.0 LAKE ENHANCEMENT ALTERNATIVES

5.1 Approach

In addition to diagnosing pollutant loadings in the five subwatersheds, this diagnostic feasibility study is intended to identify pollutant reduction alternatives and to select one or more promising alternatives for further study or design. For the purposes of lake enhancement, we have focused our study on alternative methods to reduce sediment and phosphorus loadings to Cedar Lake. While there is evidence that other pollutants are impairing lake use (*Escherichia coli* numbers impairing contact recreation, PCB concentrations impairing fish consumption), reductions in sediment and phosphorus loadings will generally have significant benefits to lake water quality.

Previous studies (Harza, 1999a) indicated phosphorus is the nutrient limiting primary productivity in the lake; reductions in phosphorus availability will increase water clarity and decrease algae and chlorophyll levels. Today at Cedar Lake, nonpoint sources, coupled with internal recycling, of phosphorus are the greatest causes of water quality degradation. Nonpoint source control of phosphorus inputs to the lake is generally linked with control of soil erosion and sedimentation through Best Management Practices (BMPs) and/or sediment traps. Phosphorus is generally transported in streams adsorbed to soil particles, so removal of the soil particles from the stream system frequently removes incoming phosphorus as well.

5.2 Identification of Enhancement Alternatives

Appendix D contains a summary of BMPs applicable to the watershed and inlets into Cedar Lake. In general, impoundments and filters address the result of erosion and excess nutrients while land management practices act to reduce erosion and excess nutrients from entering waterways. The most effective management alternatives will utilize both of these techniques.

5.3 Recommended BMPs

5.3.1 Constructed Wetlands

Over the last two decades, interest has increased for the use of constructed wetlands for treatment of nonpoint source pollution. Constructed wetlands are designed specifically for water treatment and serve in a similar capacity as other water quality BMPs, to minimize pollution prior to its entry into streams, lakes and other receiving waters. Construction of a constructed wetland is planned for the Sleepy Hollow Ditch watershed

Among the most important treatment process in wetlands are the purely physical processes of sedimentation. Sedimentation accounts for the relatively high removal rates for suspended solids, the particulate fraction of organic matter and sediment-bound nutrients and metals. Pathogens show good removal rates in constructed wetlands via sedimentation, natural die-off, and UV degradation. Dissolved constituents such as soluble organic matter, ammonia and ortho-phosphorus tend to have lower removal rates. Soluble organic matter is largely degraded aerobically by bacteria and periphyton. Ammonia is removed through microbial nitrification-denitrification, plant uptake, and volatilization. Nitrate is removed through denitrification and plant uptake. Phosphorus is removed mainly through soil sorption, plant assimilation and burial. Phosphorus removal rates are variable and typically trail behind those of nitrogen.

General ranges of removal for various pollutants by constructed wetlands are given below (Table 5-1).

TABLE 5-1

CONSTRUCTED WETLAND POLLUTANT REMOVAL EFFICIENCY (SOURCE: SCHUELER, 1987, SCHUELER *ET AL.* 1992)

Pollutant	Efficiency
Bacteria	High
Oil and Grease	Very high
BOD	Moderate
Trace metals (sediment-bound)	High
Sediment	High
Total Phosphorus	High
Total Nitrogen	Moderate

Development of constructed wetlands for treatment remains an emerging technology and design criteria continue to evolve. General design considerations include the requirement to reduce runoff velocities and provide opportunities for sedimentation. Generally designers attempt to maximize the hydraulic residence time and the distribution of flow over the treatment area.

Constructed wetlands can be a very effective part of a BMP system. Given the high nutrient concentrations in the study area's streams, constructed wetlands should be considered for development in high priority subwatersheds: Condos, North Point Marina, and Old Bank Building inlets. Potential locations are shown in Figures 7, 8, and 9. Costs for development of wetlands can vary with size, site topography and other factors. Wetlands are generally sized according to treatment needs for the volume and quality of inflows. In general, any size of wetland that slows flow velocity will result in some improvement in water quality by settling out coarser sediment. Those wetlands that retain flow for extended periods of time (many hours) generally provide greater water quality improvements by settling our fines and suspended sediment. A rule-or-thumb estimate suggests that a wetland should be sized to be at least 1% of the watershed area. Using this estimate, the following wetland sizes would be required:

- Old Bank Building – a 1.6 acre wetland
- North Point Marina – two 1.6 acre wetlands
- Condo – a 1.8 acre wetland

In all three locations, a fraction of this land is potentially available. For the Old Bank Building, and Condo inlets, facilities can be constructed in Cedar Lake. This option will allow the structure to be sized much larger. Complications of constructing in the lake include the concern of boat traffic around the structure, the difficulties of maintenance and removal of sediment, and most likely a more difficult permitting process.

A linear wetland design using the existing stream channel is recommended for the North Point Marina inlets as it is not feasible to build in the lake in this area because of the boat traffic coming out of the marina. A properly designed system can be cheaply designed and constructed in the existing stream channels near North Point Marina to slow water velocities enough to trap some inflowing sediment.

Treatment wetland unit costs can range from $5,000 per acre to upwards of $25,000 per acre. A cost estimate for a typical system that utilizes sheetpile to slow or pond water and is integrated into the existing landscape, requiring minimal earthwork is provided in Table 5-2. It is expected that wetlands designed and constructed in the Condos, Old Bank Building, or North Point Marina inlet would be similar and therefore, this cost estimate is applicable for all locations. Wetland construction requires permits from the US Army Corps of Engineers, the IDNR, Indiana Department of Environmental Management (IDEM) and, if the site in on a regulated drain, the approval of the County Drainage Board.

TABLE 5-2

ESTIMATED WETLAND CONSTRUCTION COSTS

Item	Cost[8]	Unit	Quantity	Total
Mobilization/Demobilization	$2,000	Lump sum	1	$2,000
Surveying	$1,000	Lump sum	1	$1,000
Sheetpiling	$20	SF	165	$3,300
Rip-rap	$25	SY	12	$300
Services During Construction				$800
Engineering @ 15%				$1,100
Subtotal				$8,500
Contingency @ 25%				$2,100
Total				$10,600

5.3.2 Streambank Stabilization

Streambank stabilization can be an effective way to control sediment discharge to waterbodies. Typically only about 15-25% of erosion on upland locations will make it to a stream enabling it to be transported to a lake or major river. On the other hand, almost all streambank erosion will end up in a lake or major river as it can be easily collected and transported. Therefore, if bank erosion is severe, this can be a major source of the sediment load.

The streambanks along the Golf Course Inlet are severely eroding. The sediments in the bottom of the channel are likely saturated with nutrients as drainage from the golf course is likely to contain fertilizer residuals. It is recommended that the CLEA assist the South Shore Country Club in stabilizing their streambanks. The length of the channel in this watershed is approximately 2,500 feet. Assuming an average installed cost of $50 per foot for biological treatment such as plugged coir fiber rolls, the estimated cost to stabilize both banks for the entire length of channel would be $250,000. If funds are not available to stabilize the whole channel, those portions closest to the lake should get priority. With a vegetative system such as coir fiber rolls that can be installed directly into the channels, land loss and disturbance will be minimal.

5.3.3 Fertilizer Management/Litter Control

Fertilizer management involves control of the rate, timing and method of fertilizer application in urban areas so that plant nutrients are met while minimizing the chance of polluting surface water. Fertilizer management can be an effective practice for the control of nutrients from landscaped areas. Phosphorus is the major fertilizer component of concern because it is a primary cause of lake enrichment. Existing lawns should be aerated with a coring machine before fertilizer is applied and application rates should be based upon soil testing. It is recommended that a nutrient management plan be prepared for the South Shore Golf Course. Technical assistance can be provided by the CLEA and the Lake County NRCS.

Litter control involves the removal of litter from streets and other surfaces before runoff or wind moves these materials to surface water. A major source of phosphorus in urban runoff is leaves and lawn clippings. Removing these materials before they enter surface waters can reduce phosphorus loadings significantly.

5.3.4 Agricultural Land Management Practices

Although the subwatersheds currently under study are in largely wooded and urban areas, other lake subwatersheds are largely agricultural. Increased use of conservation tillage (>30% of ground covered with plant residue) provided by no-till/strip-till, ridge-till and mulch-till systems can decrease erosion and transport from agricultural row-crop land by as much as 90%. All Indiana counties have extension agents available to provide technical assistance for implementing conservation tillage programs. Additionally, help can be obtained for conservation buffers and nutrient management plans from the local extension office.

---

[8] Installed costs. Does not include engineering design costs, land purchase or rental costs, or contract administration costs.

5.4 Funding Sources

There are several agencies providing funding for projects which address water quality, erosion control, storm water, nonpoint source pollution, wetlands, and wildlife. Funding agencies include the branches of the United States Department of Agriculture (Natural Resources Conservation Service (NRCS) and the United States Forest Service), branches of the United States Department of Interior (Fish and Wildlife Service and the Bureau of Reclamation), the United States Environmental Protection Agency, and the United States Corps of Engineers. Many of these funding agencies provide money to the states, which in turn, fund such programs as IDEM's Section 319 Nonpoint Source (NPS) Program. Other programs are financed at the state level, such as the LARE Program.

These programs include both grants and loans. In general, most of the programs require cost share requirements specifying non-federal contributions from 5 to 75%. There is currently policy and programmatic revisions underway at IDEM that will make non-point source control project eligible for financing by the State Revolving Loan Fund. This is an important new facet of the SRF and presents a significant financial resource for watershed managers in the state.

The SRF was created by the Clean Water Act Amendments in 1987 and has most commonly been used to finance municipal wastewater collection and treatment projects. Indiana's SRF Program offers low-interest loans to qualified communities for the planning, design, and construction of publicly-owned wastewater facilities. The SRF currently provides the lowest cost financing for these wastewater projects. The program is jointly managed by the IDEM and the State Budget Agency (SBA). IDEM is SRF Program administrator and the SBA is financial manager. Currently, IDEM is revising its policy and, in a year or so, nonpoint source projects will be eligible for SRF financing. Together, the EPA and the State of Indiana have provided over $342 million to the SRF through 1998. Although future funding is uncertain, the program will be self-sustaining through the repayment of the loans. Communities eligible to apply for SRF loans are political subdivisions including incorporated cities and towns, counties, townships, municipal corporations, conservancy districts, sanitary districts, and regional water, sewer and waste districts.

The 1995 session of the General Assembly passed Senate Bill 66 to provide a three-tiered interest rate policy for the SRF program. The new policy allows the SRF program to be more affordable to communities, especially Indiana's poorer communities. The interest rate available to a community is based on the median household income (MHI) of the service area. In addition, a community may be eligible for 0% interest for up to two years depending upon the communities' MHI. The SRF can be utilized by CLEA if they have projects sponsored by the Town of Cedar Lake or the Lake County NRCS.

6.0 CONCLUSIONS AND RECOMMENDATIONS

This diagnostic study has examined the chemical effects of nonpoint source pollution on Cedar Lake. We have examined water quality in five smaller subwatersheds that discharge into the lake. Estimates of nonpoint source loadings were developed for all five. Accordingly, we ranked the subwatersheds for BMPs based on areal sediment and phosphorus loading rates. It was shown that the Condos inlet followed by North Point Marina and Old Bank Building inlets contribute more than 13 times more nonpoint source pollution than do the North and Golf Course inlets; therefore, enhancement efforts should address these sources first.

6.1 Best Management Practices (BMPs)

The overall Cedar Lake watershed is heavily agricultural (~50%). There is a broad range of BMPs for agricultural lands. Some of the most effective BMPs include conservation tillage, conservation buffers and nutrient management. Conservation tillage should continue to be a focus of Lake County NRCS efforts. Improved subwatershed water quality will coincide with increased conservation tillage and use of other BMPs as well.

Fertilizer management on fields, lawns, and golf courses and decreased organic matter discharges (leaves and grass clippings) into streams will be affected in lower stream and lake phosphorus concentrations.

6.2 Institutions

The CLEA should continue to educate local landowners through their efforts. Recommendations are for the CLEA to continue to obtain funds to develop an engineering feasibility study for constructed wetlands in high priority subwatersheds, the Condos, North Point Marina, and the Old Bank Building. CLEA and the Lake County NRCS should offer technical assistance to the South Shore Country Club to prepare a nutrient management plan. Additionally, it is recommended that the CLEA obtain funds to produce fact-filled brochures or newspaper articles on how landowners can help to improve water quality.

6.3 Projects

Constructed wetlands can be a very effective part of a BMP system. Given the high sediment and nutrient concentrations in the study area streams, constructed wetlands should be considered for development in high priority subwatersheds: Condos, North Point Marina, and Old Bank Building inlets. It should be determined if land owners will allow easements for these small parcels of land that wetlands are proposed on. If so, more detailed siting, layout, and design for the wetlands can be evaluated. We recommend that the CLEA seek the involvement of local landowners in these three drainages, explain the need for and the project, and solicit their input, involvement and support in constructing wetlands in these areas to improve Cedar Lake's water quality. The North Point Marina inlet should receive priority as it has the largest studied watershed and is ranked among the highest for sediment and nutrients. Additionally, more land is potentially available in this location compared with others providing for a much easier and less costly design then will be required for the Condo and Old Bank Building inlets. A design for the North Point Marina inlets should utilize the existing stream channel and topography as much as possible. This will not only minimize land requirements; but, it will also considerably lower construction costs and decrease design complexity.

Streambank stabilization can effectively improve water quality and aesthetics of the Golf Course inlet. It is suggested that vegetative bank stabilization techniques be constructed on as many lineal feet of bank as funds are available. We recommend that the CLEA seek permission and involvement of the South Shore Country Club in this endeavor.

7.0 REFERENCES

Echelberger, Jr., W.F., Jones, W.W., and others, 1979. Cedar Lake Restoration Feasibility Study, Environmental Systems Application Center, School of Public and Environmental Affairs, Indiana University, Bloomington, IN.

Echelberger, Jr., W.F., Jones, W.W., and others, 1984. Cedar Lake Restoration Feasibility Study - Final Report, Environmental Systems Application Center, School of Public and Environmental Affairs, Indiana University, Bloomington, IN.

Harza Engineering Company, 1999a. Cedar Lake Engineering Feasibility Study.

Harza Engineering Company, 1999b. Quality Assurance Project Plan for Cedar Lake Watershed Diagnostic Study, Cedar Lake, Indiana, ARN# 99-221.

Indiana GAP Database. GIS Land Use Themes.

Jones, W. W. and Marnatti, J., 1991. Cedar Lake Enhancement Study - Final Report, Environmental Systems Application Center, School of Public and Environmental Affairs, Indiana University, Bloomington, IN.

Mills, W.B., D.B. Oircella, M.J. Ungs, and others, 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water. EPA/600/6-85/002a.

Schueler, T.R., 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Publication no. 87703. Metropolitan Washington Council of Governments. 275pp.

Schueler, T.R. P.A. Kumble, and M.A. Heraty. 1992. A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution In the Coastal

Zone. Publication no. 92705. Metropolitan Washington Council of Governments. Washington, DC. 127pp.

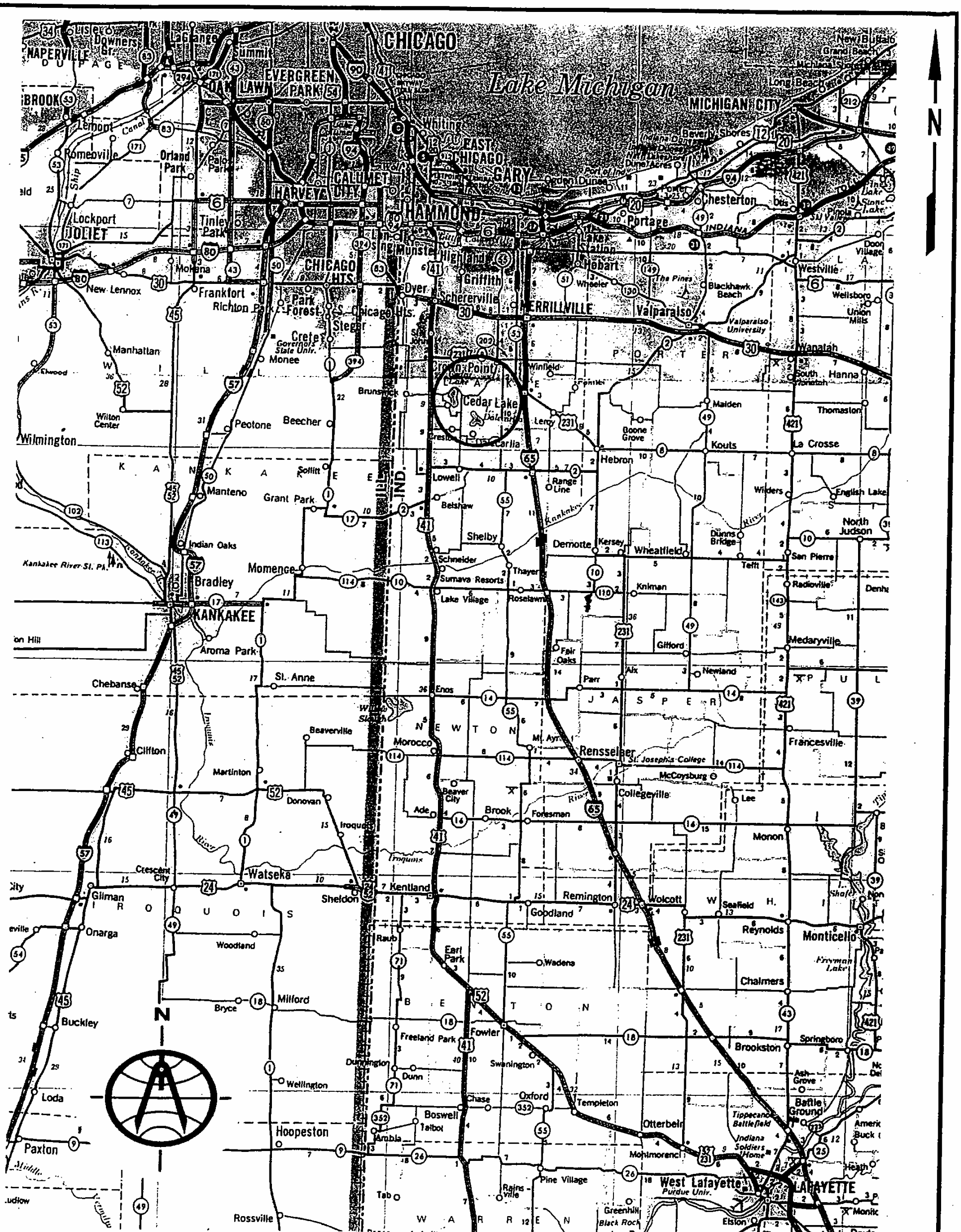
Soil Conservation Service. 1972. National Engineering Handbook. Section 4. Hydrology. U.S. Department of Agriculture.

United States Department of Agriculture, Soil Conservation Service, 1992. Soil Survey of Lake County, Indiana.

United States Environmental Protection Agency, 1997. Compendium of Tools for Watershed Assessment and TMDL Development. EPA841-B-97-006.

United States Department of Interior, Fish and Wildlife Service, 1981. National Wetlands Inventory Quad Maps of Lowell, Indiana and St. John, Indiana.

FIGURES



Scale 0 2000 Feet

Approximate Scale

Figure 1

GENERAL LOCATION MAP

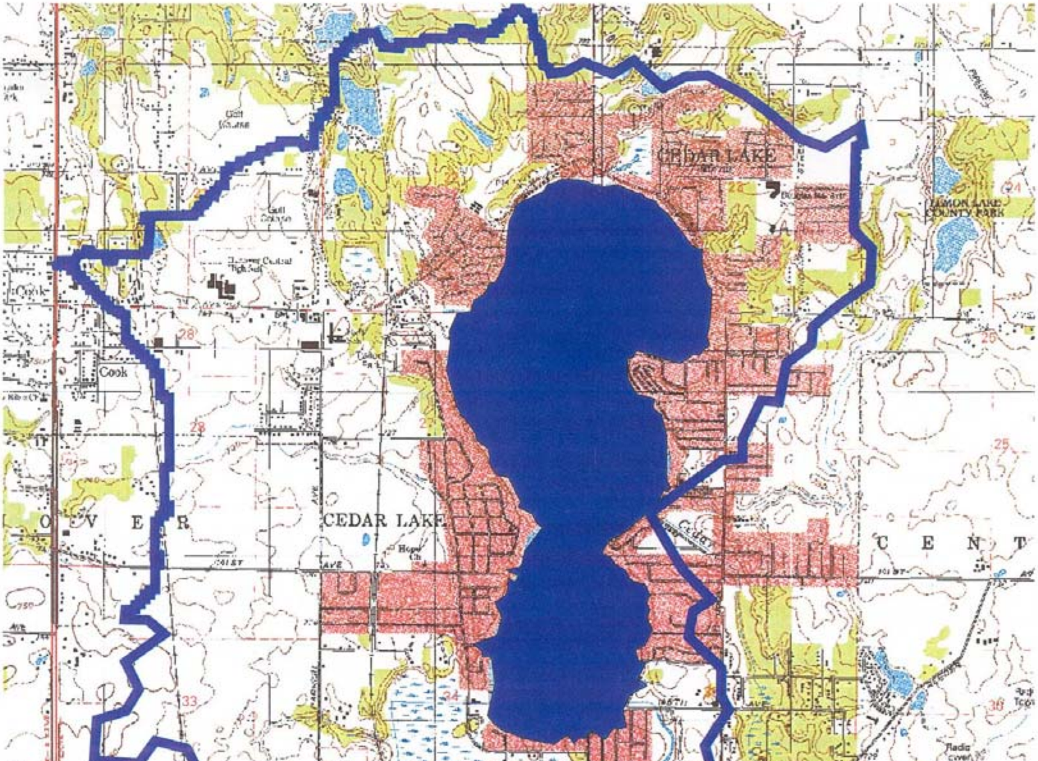
CEDAR LAKE DIAGNOSTIC FEASIBILITY STUDY

Cedar Lake, Indiana

HARZA ENGINEERING COMPANY

WATER & ENVIRONMENT

o:/cedar/figure1.cdr

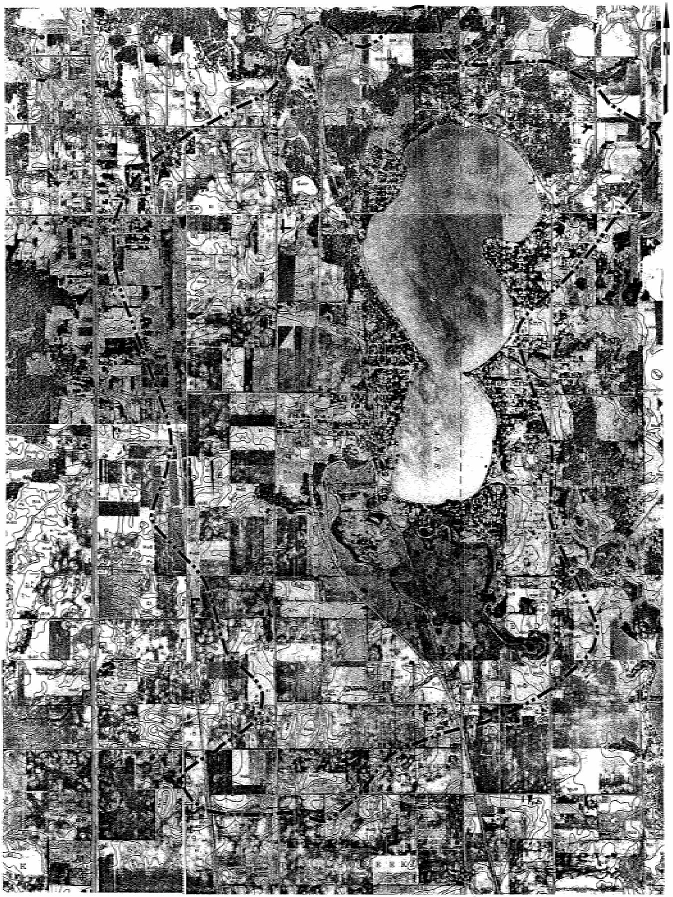


N

HARZA

1500 0 1500 3000 4500 Feet

Figure 2
Watershed Map
Cedar Lake Diagnostic Feasibility Study
Cedar Lake, Indiana



LEGEND:

Watershed Boundary

SCALE 0 2000 4000 Feet

1"=2000'-0"

HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

Figure 4
SOILS MAP
CEDAR LAKE DIAGNOSTIC FEASIBILITY STUDY
Cedar Lake, Indiana

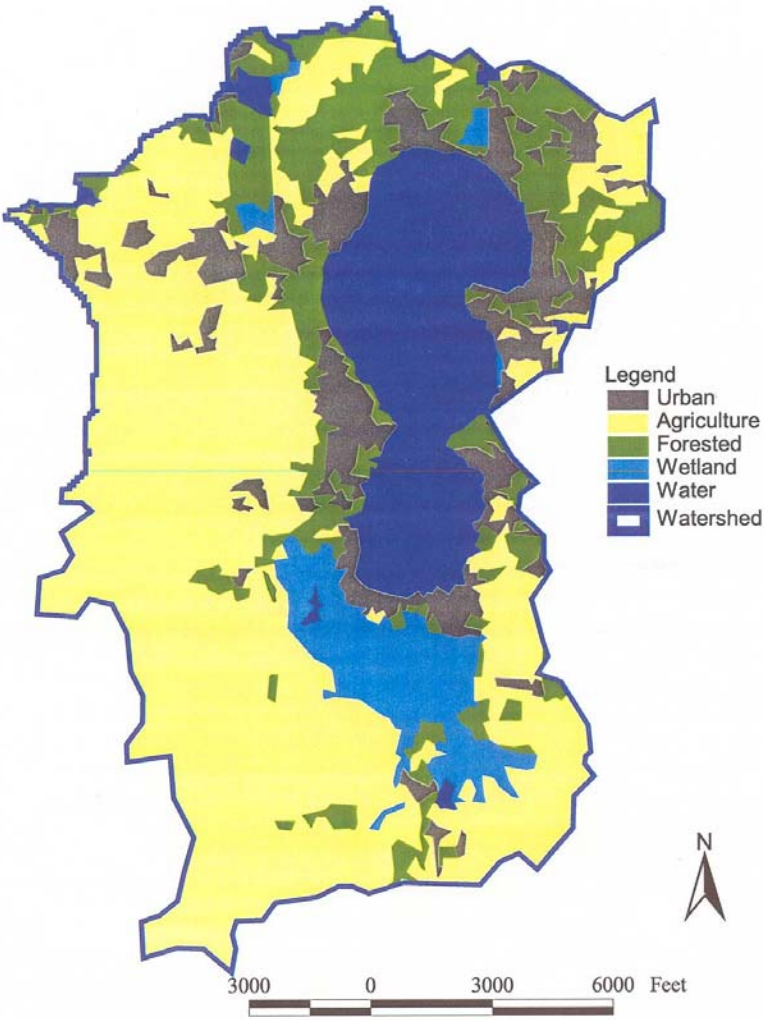


Figure 3
Land Use Map
Cedar Lake Diagnostic Feasibility Study
Cedar Lake, Indiana

HARZA

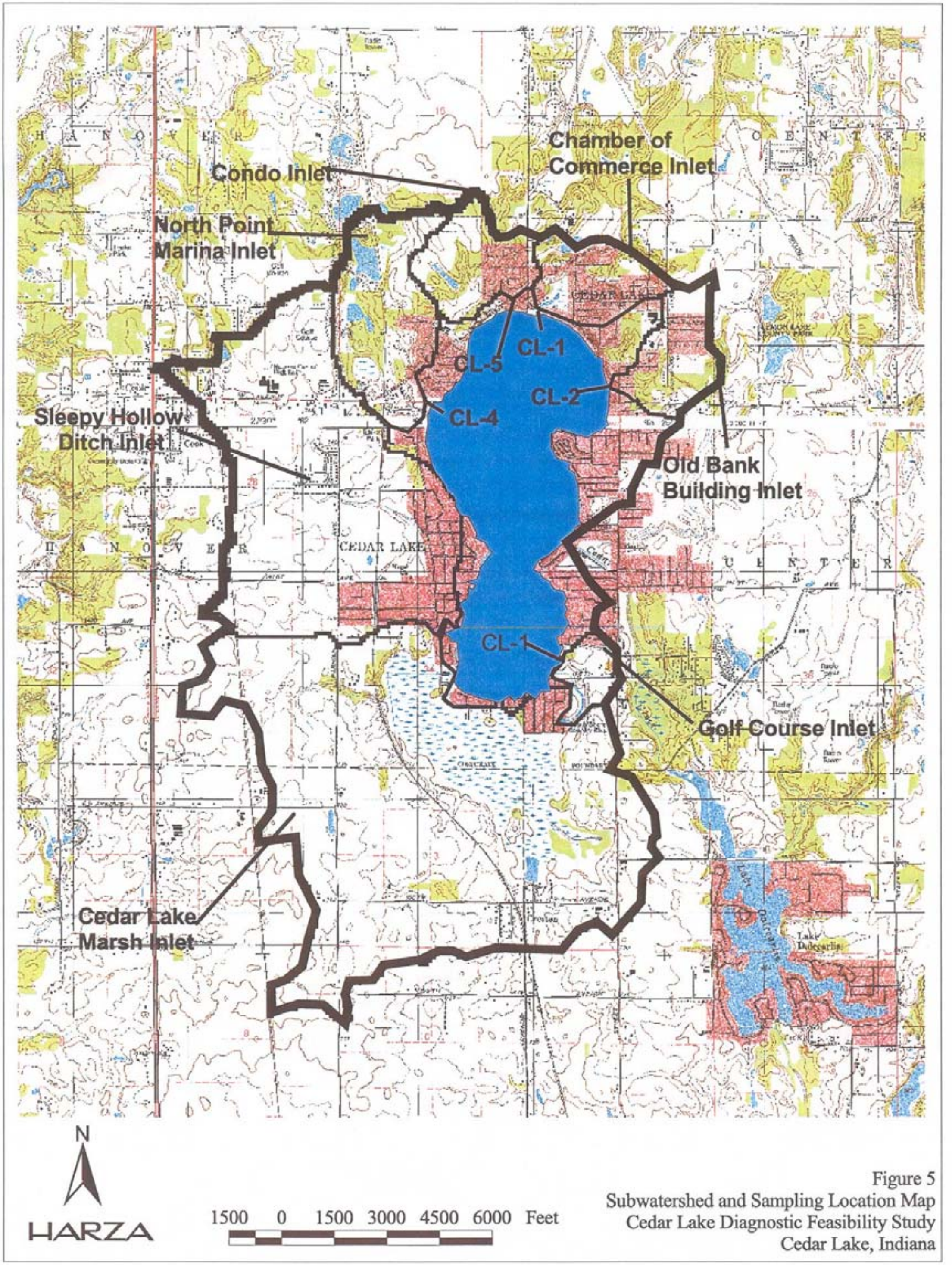


Figure 5
Subwatershed and Sampling Location Map
Cedar Lake Diagnostic Feasibility Study
Cedar Lake, Indiana

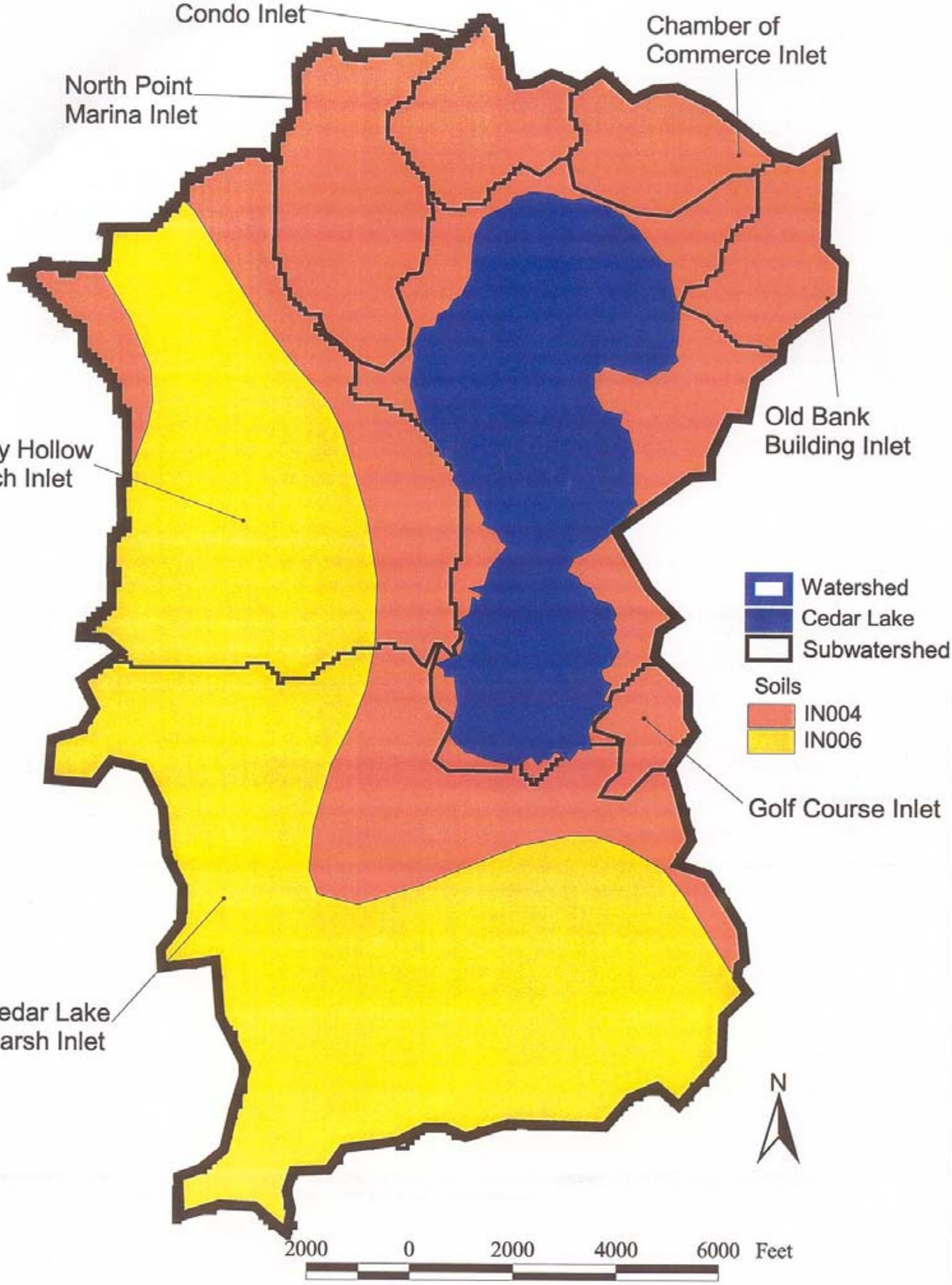
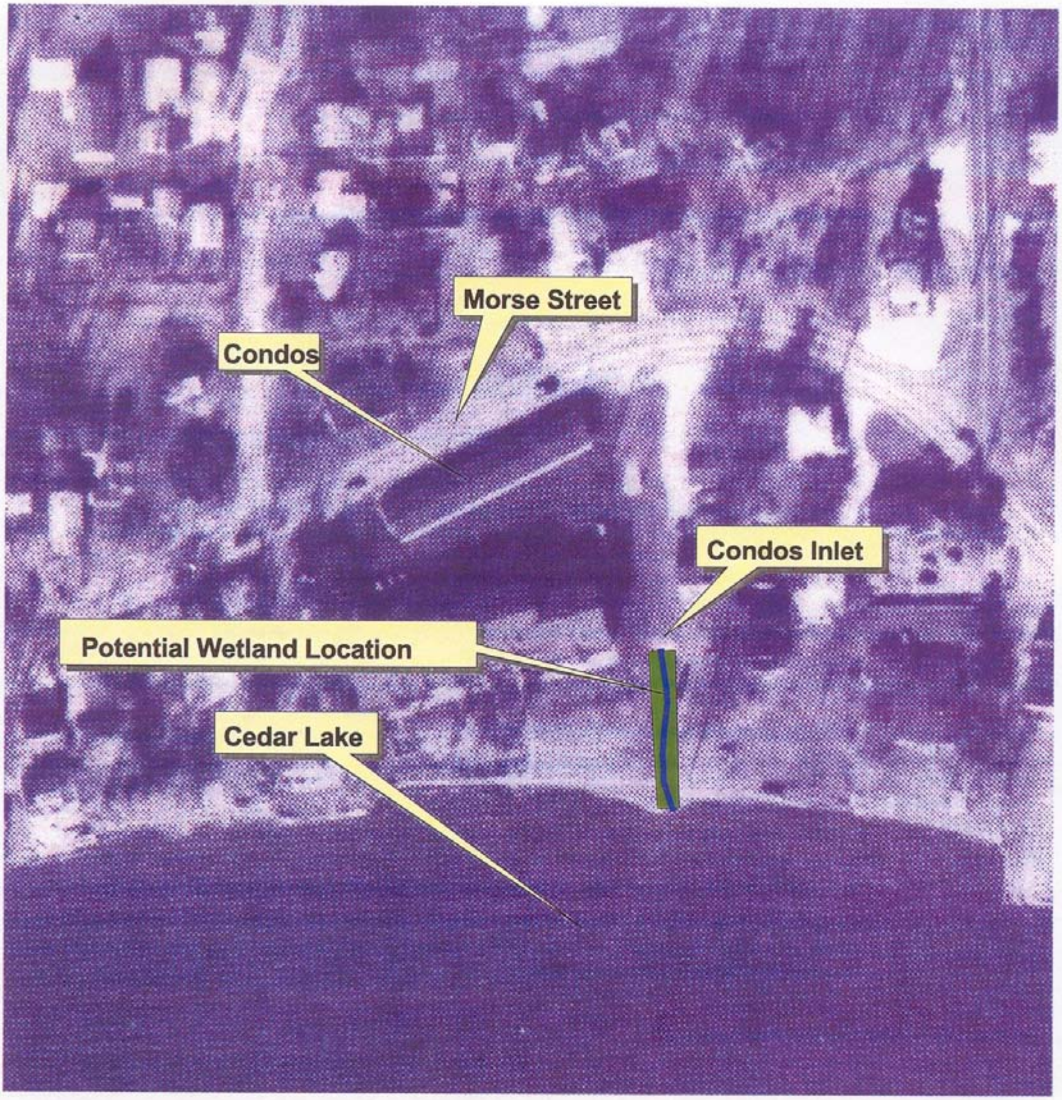


Figure 6
STATSGO Soil Information Map
Cedar Lake Diagnostic Feasibility Study
Cedar Lake, Indiana

HARZA



HARZA

Figure 7
Potential Wetland Location (Condos Inlet)
Cedar Lake Diagnostic Feasibility Study
Cedar Lake, Indiana

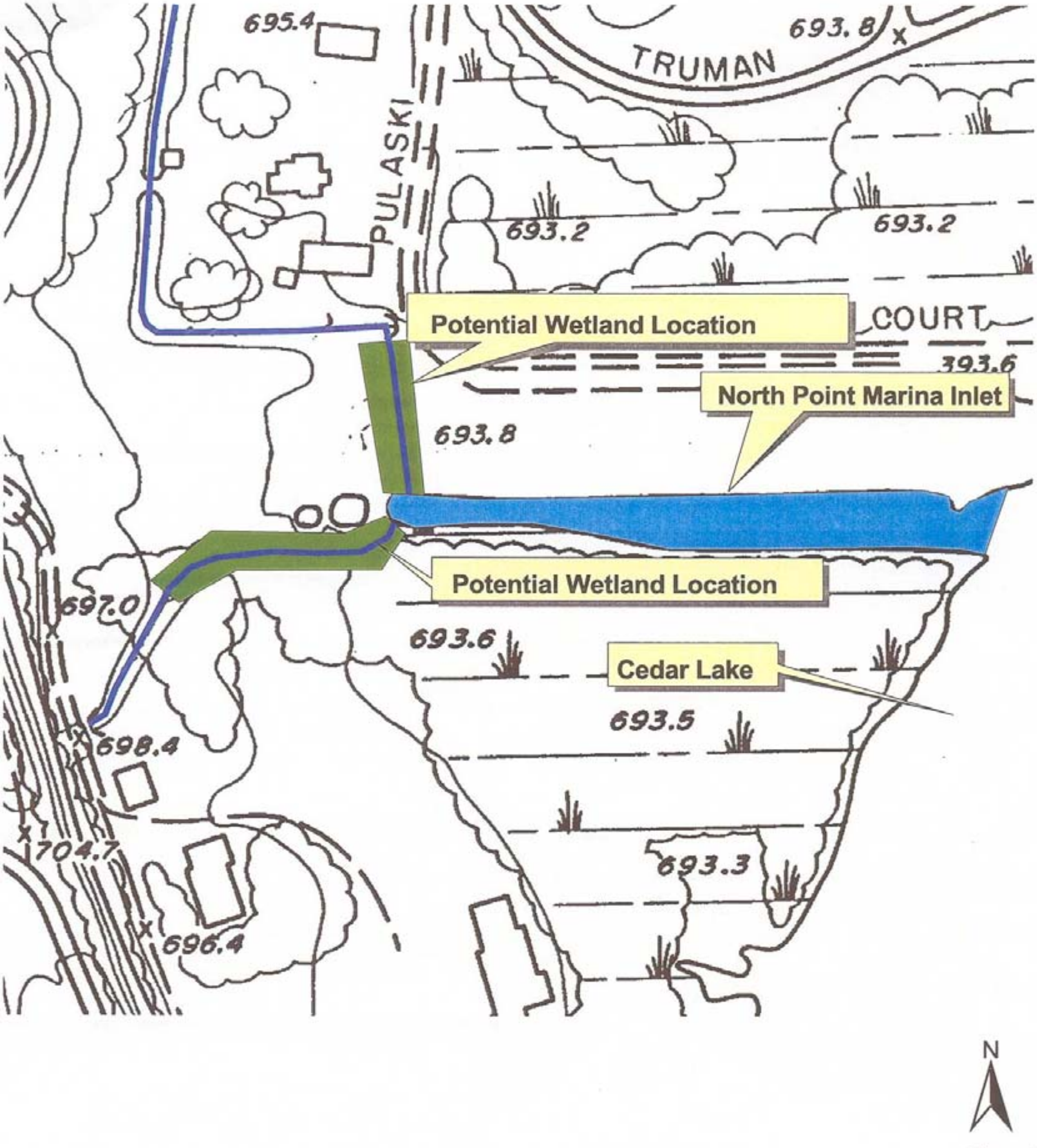


Figure 8
Potential Wetland Location (North Point Marina)
Cedar Lake Diagnostic Feasibility Study
Cedar Lake, Indiana

HARZA

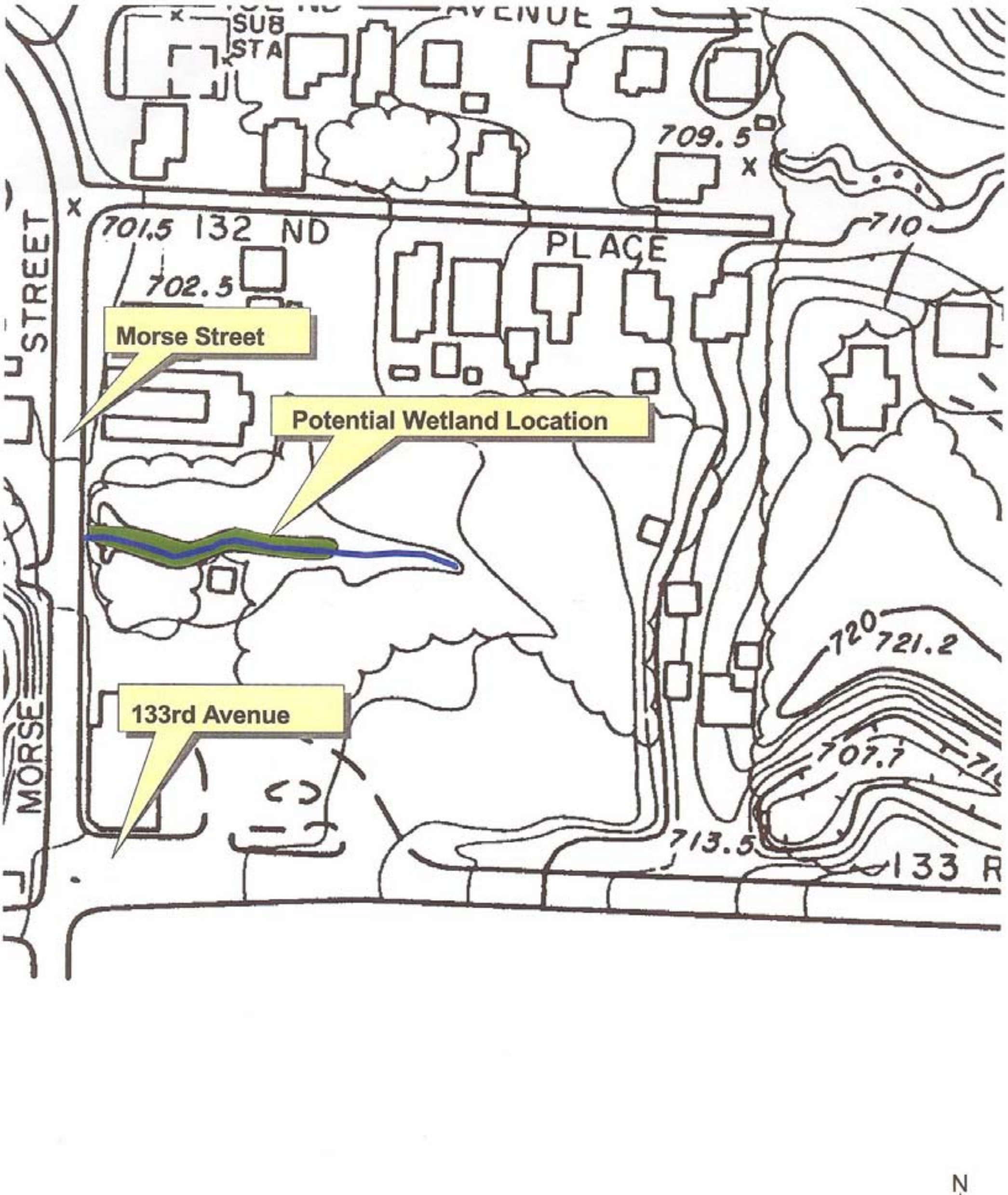


Figure 9
Potential Wetland Location (Old Bank Building)
Cedar Lake Diagnostic Feasibility Study
Cedar Lake, Indiana

HARZA

APPENDICES

APPENDIX A

CEDAR LAKE PHOTOLOG

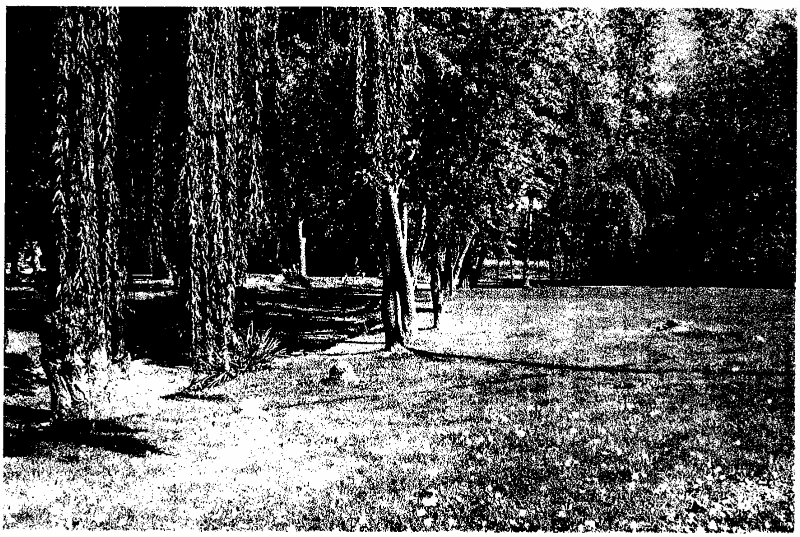
Picture 1: Inlet by the Old Bank Building.

Picture 2: Old Bank Building Inlet on east side of road.

Picture 3: Chamber of Commerce Wetland during storm event.

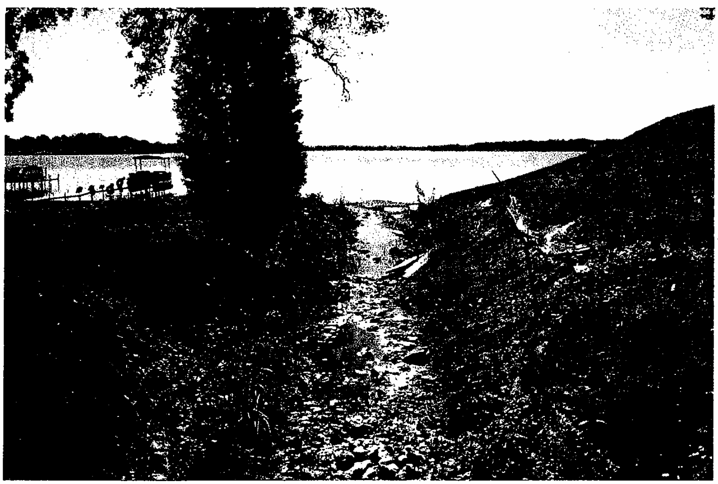
Picture 4: Chamber of Commerce Wetland during dry weather.

Picture 5: Chamber of Commerce inlet.

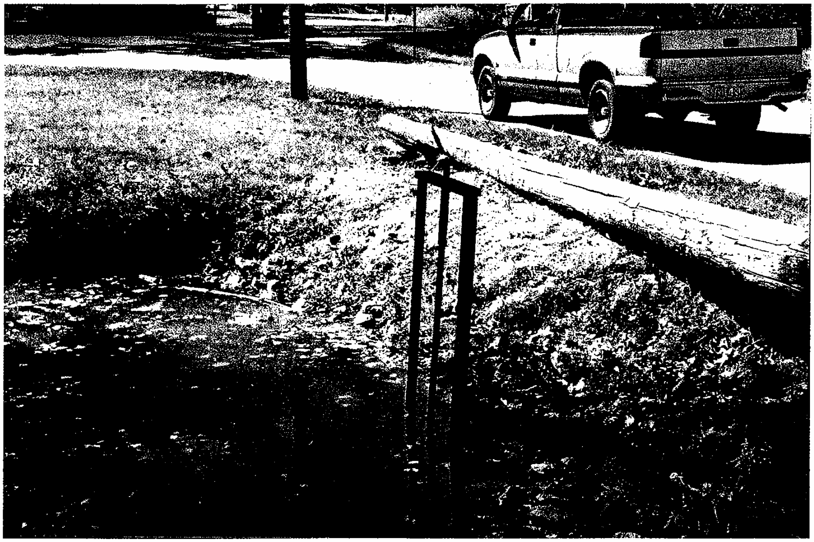


Picture 6: Chamber of Commerce Wetland watershed.

Picture 7: North inlet into North Point Marina.



Picture 8: Condos Inlet.



Picture 9: Weir at Golf Course Inlet.

Picture 10: Failing stream banks at Golf Course Inlet.

Picture 11: Golf Course Inlet watershed.

APPENDIX B

TestAmerica
INCORPORATED

Mr. Chris Barden
HARZA ENGINEERING COMPANY
233 S. Wacker Drive
Chicago, IL 60606

03/07/2000

Job Number: 00.01809

IEPA Cert. No.: 100221
WDNR Cert. No.: 999447130

Enclosed is the Analytical and Quality Control reports for the following samples submitted to Bartlett Division of TestAmerica for analysis.

Project Description: Cedar Lake, Indiana/Proj. #15825 13.300

Sample Number	Sample Description	Date Taken	Date Received
568659	CL-1 North Inlet	02/28/2000	02/28/2000
568660	CL-2 Old Bank Bldg	02/28/2000	02/28/2000
568661	CL-3 Golf Course	02/28/2000	02/28/2000

Sample analysis in support of the project referenced above has been completed and results are presented on the following pages. These results apply only to the samples analyzed. Reproduction of this report only in whole is permitted. Please refer to the enclosed "Key to Abbreviations" for definition of terms. Procedures used follow TestAmerica Standard Operating Procedures which reference the methods listed on your report. Should you have questions regarding procedures or results, please do not hesitate to call. TestAmerica has been pleased to provide these analytical services for you.

This Quality Control report is generated on a batch basis. All information contained in this report is for the analytical batch(es) in which your sample(s) were analyzed.

Approved by:
Mary Pearson

Mary Pearson
Project Manager

TestAmerica
INCORPORATED

ANALYTICAL REPORT

Mr. Chris Barden
HARZA ENGINEERING COMPANY
233 S. Wacker Drive
Chicago, IL 60606

03/07/2000

Sample No. : 568659

Job No.: 00.01809

Sample Description: CL-1 North Inlet
Cedar Lake, Indiana/Proj. #15825 13.300

Date Taken: 02/28/2000
Time Taken: 10:05

Date Received: 02/28/2000
Time Received: 15:30

Analyte	Result	Flag	Units	Reporting Limit	Date Analyzed	Analyst Initials	Analytical Method
BOD, Five Day	<4		mg/L	4	03/01/2000	mpe	SM 5210B
N-Ammonia	<0.50		mg/L	0.50	03/02/2000	jrr	EPA 350.1
N-Nitrate	1.8		mg/L	1.0	02/29/2000	aks	SM 4500NO3
Phosphorus, Ortho	0.12		mg/L	0.06	02/29/2000	jrr	EPA 365.2
Phosphorus, Total	0.19		mg/L	0.02	03/03/2000	jrr	SM 4500P E
Solids, Total Suspended	<5		mg/L	5	03/03/2000	lmf	USG I-3765-85

850 W. Bartlett Rd. / Bartlett, IL 60103-4400 / 630-289-3100 / Fax: 630-289-5445 / 800-378-5700

TestAmerica
INCORPORATED

ANALYTICAL REPORT

Mr. Chris Barden
HARZA ENGINEERING COMPANY
233 S. Wacker Drive
Chicago, IL 60606

03/07/2000

Sample No. : 568660

Job No.: 00.01809

Sample Description: CL-2 Old Bank Bldg
Cedar Lake, Indiana/Proj. #15825 13.300

Date Taken: 02/28/2000
Time Taken: 10:15

Date Received: 02/28/2000
Time Received: 15:30

Analyte	Result	Flag	Units	Reporting Limit	Date Analyzed	Analyst Initials	Analytical Method
BOD, Five Day	<4		mg/L	4	03/01/2000	mpe	SM 5210B
N-Ammonia	<0.50		mg/L	0.50	03/02/2000	jrr	EPA 350.1
N-Nitrate	1.7		mg/L	1.0	02/29/2000	aks	SM 4500NO3
Phosphorus, Ortho	0.04		mg/L	0.06	02/29/2000	jrr	EPA 365.2
Phosphorus, Total	0.04		mg/L	0.02	03/03/2000	jrr	SM 4500P E
Solids, Total Suspended	58		mg/L	5	03/03/2000	lmf	USG I-3765-85

850 W. Bartlett Rd. / Bartlett, IL 60103-4400 / 630-289-3100 / Fax: 630-289-5445 / 800-378-5700

TestAmerica
INCORPORATED

ANALYTICAL REPORT

Mr. Chris Barden
HARZA ENGINEERING COMPANY
233 S. Wacker Drive
Chicago, IL 60606

03/07/2000

Sample No. : 568661

Job No.: 00.01809

Sample Description: CL-3 Golf Course
Cedar Lake, Indiana/Proj. #15825 13.300

Date Taken: 02/28/2000
Time Taken: 10:30

Date Received: 02/28/2000
Time Received: 15:30

Analyte	Result	Flag	Units	Reporting Limit	Date Analyzed	Analyst Initials	Analytical Method
BOD, Five Day	<4		mg/L	4	03/01/2000	mpe	SM 5210B
N-Ammonia	<0.50		mg/L	0.50	03/02/2000	jrr	EPA 350.1
N-Nitrate	1.0		mg/L	1.0	02/29/2000	aks	SM 4500NO3
Phosphorus, Ortho	0.04		mg/L	0.06	02/29/2000	jrr	EPA 365.2
Phosphorus, Total	0.05		mg/L	0.02	03/03/2000	jrr	SM 4500P E
Solids, Total Suspended	46		mg/L	5	03/03/2000	lmf	USG I-3765-85

850 W. Bartlett Rd. / Bartlett, IL 60103-4400 / 630-289-3100 / Fax: 630-289-5445 / 800-378-5700

TestAmerica, Bartlett Division

KEY TO ABBREVIATIONS and METHOD REFERENCES

<	:	Less than; When appearing in the results column indicates the analyte was not detected at or above the reported value.
mg/L	:	Concentration in units of milligrams of analyte per liter of sample. Measurement used for aqueous samples. Can also be expressed as parts per million (ppm).
ug/g	:	Concentration in units of micrograms of analyte per gram of sample. Measurement used for non-aqueous samples. Can also be expressed as parts per million (ppm) or mg/Kg.
ug/L	:	Concentration in units of micrograms of analyte per liter of sample. Measurement used for aqueous samples. Can also be expressed as parts per billion (ppb).
ug/Kg	:	Concentration in units of micrograms of analyte per kilogram of sample. Measurement used for non-aqueous samples. Can also be expressed as parts per billion (ppb).
TCLP	:	These initials appearing in front of an analyte name indicate that the Toxicity Characteristic Leaching Procedure (TCLP) was performed for this test.
Surr:	:	These initials are the abbreviation for surrogate. Surrogates are compounds that are chemically similar to the compounds of interest. They are part of the method quality control requirements.
%	:	Percent; To convert ppm to %, divide the result by 10,000. To convert % to ppm, multiply the result by 10,000.
ICP	:	Indicates analysis was performed using Inductively Coupled Plasma Spectroscopy.
AA	:	Indicates analysis was performed using Atomic Absorption Spectroscopy.
GFAA	:	Indicates analysis was performed using Graphite Furnace Atomic Absorption Spectroscopy.
PQL	:	Practical Quantitation Limit; the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions.

Method References

(1) Methods 1000 through 9999: see "Test Methods for Evaluating Solid Waste", USEPA SW-846, 3rd Edition, 1986.

(2) ASTM "American Society for Testing Materials"

(3) Methods 100 through 499: see "Methods for Chemical Analysis of Water and Wastes", USEPA, 600/4-79-020, Rev. 1983.

(4) See "Standard Methods for the Examination of Water and Wastewater", 17th Ed, APHA, 1989.

(5) Methods 600 through 625: see "Guidelines Establishing Test Procedures for the Analysis of Pollutants", USEPA Federal Register Vol. 49 No. 209, October 1984.

(6) Methods 500 through 599: see "Methods for the Determination of Organic Compounds in Drinking Water," USEPA 600/4-88/039, Rev. 1988.

(7) See "Methods for the Determination of Metals in Environmental Samples", Supplement I EPA-600/R-94/111, May 1994.

(8) See "Standard Methods for the Examination of Water and Wastewater", 18th Ed., APHA, 1992.

(9) Methods 1000 through 9999: see "Test Methods for Evaluating Solid Waste", USEPA SW-846, 3rd Edition, 1986, Including Updates I and II.

(10) This method is from the 2nd Edition of "Test Methods for Evaluating Solid Waste", USEPA SW-846. It has been dropped from the 3rd Edition, 1986.

HARZA *Consulting Engineers and Scientists*　　　　　　　　1026

SEARS TOWER • 233 South Wacker Drive • Chicago, Illinois 60606-6392　Tel: (312) 831-3800 • Fax: (312) 831-3999 • Telex: 25-3540

CHAIN OF CUSTODY RECORD

SITE: Cedar Lake, Indiana	COOLER No.
SAMPLER: (Signature) [signature]	PROJECT No. 15825 13.300

FIELD SAMPLE NUMBER	DATE	TIME	COMP.	GRAB	STATION LOCATION	No. OF CONTAINERS	Ortho-P	TSS	Ammonia	Nitrate	BOD	Total P				REMARKS
CL-1	2/28/00	10:05		✓	North Inlet	4	✓	✓	✓	✓	✓	✓			#16	Correct time is in red
CL-2	↓	10:15		✓	Old Bank Bldg	4	✓	✓	✓	✓	✓	✓			#17	" Date is in red
CL-3	↓	10:30		✓	Golf Course	4	✓	✓	✓	✓	✓	✓			#18	

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Relinquished by: (Signature)	Date	Time	Received by: (Signature)
[signature]	2-28-00	2:00	[signature]	[signature]	2/28/00	1530	

Relinquished by: (Signature)	Date	Time	Received for Laboratory by: (Signature)	Date	Time	Remarks:
			P. Merrill	2/28/00	1530	3°C wet ice

NORTHLAND Laboratories Dedicated to Quality Testing for the Food and Allied Industries Since 1948

Northbrook Division, Corporate Office
1818 Skokie Blvd. Northbrook, IL 60062
(847)272-8700 Fax: (847) 272-2348

Analytical Test Report

HARZA ENGINEERING COMPANY
233 SOUTH WACKER DR
CHICAGO, IL. 60606
ATTN: DOUG MULVEY

ACCOUNT : 1063
COPY : 1
DATE : 03/02/2000

LAB IDEE # : 10228991376
SAMPLE CODE : CL-1
LOT NUMBER : 2/28 10:05AM
DATE RECEIVED: 02/28/2000
P.O. NUMBER : 1027
SUBMITTER : DOUG MULVEY

REQUEST # : IL DPH #17581

DESCRIPTION: WATER, CEDAR LAKE INDIANA, NORTH INLET - 15825 B.300

TEST NAME/METHODOLOGY	RESULT	UNITS
E. COLI COUNT (MPN) Method: FDA APHA AND BAM	3	COLONY FORMING UNITS PER GRAM
FAXED REPORT Method: TRANSMISSION		

Certification Number: IL DPH #17581
USDA/FSIS - Salmonella & Listeria #0164
USDA/FSIS - Chemistry #1761

Reviewed By:______________________________

-END OF REPORT-

NORTHLAND Laboratories Dedicated to Quality Testing for the Food and Allied Industries Since 1949

Northbrook Division, Corporate Office
1818 Skokie Blvd. Northbrook, IL 60062
(847)272-8700 Fax: (847) 272-2348

Analytical Test Report

HARZA ENGINEERING COMPANY
233 SOUTH WACKER DR
CHICAGO, IL. 60606
ATTN: DOUG MULVEY

ACCOUNT : 1063
COPY : 1
DATE : 03/02/2000

LAB IDEE # : 10228991377
SAMPLE CODE : CL-2
LOT NUMBER : 2/28 10:15AM
DATE RECEIVED: 02/28/2000
P.O. NUMBER : 1027
SUBMITTER : DOUG MULVEY

REQUEST # : IL DPH #17581

DESCRIPTION: WATER, CEDAR LAKE INDIANA, OLD BAND BLDG - 15825 B.300 (REC'D FROZEN)

TEST NAME/METHODOLOGY	RESULT	UNITS
E. COLI COUNT (MPN) Method: FDA APHA AND BAM	150	COLONY FORMING UNITS PER GRAM
FAXED REPORT Method: TRANSMISSION		

Certification Number: IL DPH #17581
USDA/FSIS - Salmonella & Listeria #0164
USDA/FSIS - Chemistry #1761

Reviewed By:______________________________

-END OF REPORT-

NORTHLAND Laboratories Dedicated to Quality Testing for the Food and Allied Industries Since 1948

Northbrook Division, Corporate Office
1818 Skokie Blvd. Northbrook, IL 60062
(847)272-8700 Fax: (847) 272-2348

Analytical Test Report

HARZA ENGINEERING COMPANY
233 SOUTH WACKER DR
CHICAGO, IL. 60606
ATTN: DOUG MULVEY

ACCOUNT : 1063
COPY : 1
DATE : 03/02/2000

LAB IDEE # : 10228991378
SAMPLE CODE : CL-3
LOT NUMBER : 2/28 10:30AM
DATE RECEIVED: 02/28/2000
P.O. NUMBER : 1027
SUBMITTER : DOUG MULVEY

REQUEST # : IL DPH #17581

DESCRIPTION: WATER, CEDAR LAKE INDIANA, GOLF COURSE - 15825 B.300 (REC'D FROZEN)

TEST NAME/METHODOLOGY	RESULT	UNITS
E. COLI COUNT (MPN) Method: FDA APHA AND BAM	<3.0	COLONY FORMING UNITS PER GRAM
FAXED REPORT Method: TRANSMISSION		

Reviewed By:______________________________

-END OF REPORT-

Certification Number: IL DPH #17581
USDA/FSIS - Salmonella & Listeria #0164
USDA/FSIS - Chemistry #1761

TestAmerica
INCORPORATED

Mr. Chris Barden
HARZA ENGINEERING COMPANY
233 S. Wacker Drive
Chicago, IL 60606

03/28/2000

Job Number: 00.02692

IEPA Cert. No.: 100221
WDNR Cert. No.: 999447130

Enclosed is the Analytical and Quality Control reports for the following samples submitted to Bartlett Division of TestAmerica for analysis.

Project Description: Cedar Lake - Proj. #15825.B.300

Sample Number	Sample Description		Date Taken	Date Received
571747	CL-1	North Inlet	03/20/2000	03/20/2000
571748	CL-2	Old Bank Building	03/20/2000	03/20/2000
571749	CL-3	Golf Course	03/20/2000	03/20/2000
571750	CL-4		03/20/2000	03/20/2000
571751	CL-5		03/20/2000	03/20/2000

Sample analysis in support of the project referenced above has been completed and results are presented on the following pages. These results apply only to the samples analyzed. Reproduction of this report only in whole is permitted. Please refer to the enclosed "Key to Abbreviations" for definition of terms. Procedures used follow TestAmerica Standard Operating Procedures which reference the methods listed on your report. Should you have questions regarding procedures or results, please do not hesitate to call. TestAmerica has been pleased to provide these analytical services for you.

This Quality Control report is generated on a batch basis. All information contained in this report is for the analytical batch(es) in which your sample(s) were analyzed.

Approved by:

Mary Pearson

Mary Pearson
Project Manager

850 W. Bartlett Rd. / Bartlett, IL 60103-4400 / 630-289-3100 / Fax: 630-289-5445 / 800-378-5700

TestAmerica
INCORPORATED

ANALYTICAL REPORT

Mr. Chris Barden
HARZA ENGINEERING COMPANY
233 S. Wacker Drive
Chicago, IL 60606

03/28/2000

Sample No. : 571747

Job No.: 00.02692

Sample Description: CL-1 North Inlet
Cedar Lake - Proj. #15825.B.300

Date Taken: 03/20/2000
Time Taken: 11:00

Date Received: 03/20/2000
Time Received: 16:35

Parameter	Result	Flag	Units	Reporting Limit	Date Analyzed	Analyst Initials	Analytical Method
BOD, Five Day	<4		mg/L	2	03/21/2000	mpe	SM 5210B
N-Ammonia	<0.50		mg/L	0.50	03/22/2000	jrr	EPA 350.1
Nitrate + Nitrite	<1.0		mg/L	1.0	03/27/2000	aks	SM 4500NO3
Phosphate, Ortho	<0.06		mg/L	0.06	03/21/2000	jrr	EPA 365.2
Phosphorus, Total	0.11		mg/L	0.02	03/28/2000	jrr	SM 4500P E
Solids, Total Suspended	12		mg/L	5	03/27/2000	aks	USG I-3765-85

850 W. Bartlett Rd. / Bartlett, IL 60103-4400 / 630-289-3100 / Fax: 630-289-5445 / 800-378-5700

TestAmerica
INCORPORATED

ANALYTICAL REPORT

Mr. Chris Barden
HARZA ENGINEERING COMPANY
233 S. Wacker Drive
Chicago, IL 60606

03/28/2000

Sample No. : 571748

Job No.: 00.02692

Sample Description: CL-2 Old Bank Building
Cedar Lake - Proj. #15825.B.300

Date Taken: 03/20/2000
Time Taken: 11:05

Date Received: 03/20/2000
Time Received: 16:35

Parameter	Result	Flag	Units	Reporting Limit	Date Analyzed	Analyst Initials	Analytical Method
BOD, Five Day	<4		mg/L	2	03/21/2000	mpe	SM 5210B
N-Ammonia	<0.50		mg/L	0.50	03/22/2000	jrr	EPA 350.1
Nitrate + Nitrite	1.5		mg/L	1.0	03/27/2000	aks	SM 4500NO3
Phosphate, Ortho	0.012		mg/L	0.06	03/21/2000	jrr	EPA 365.2
Phosphorus, Total	0.18		mg/L	0.02	03/28/2000	jrr	SM 4500P E
Solids, Total Suspended	11		mg/L	5	03/27/2000	aks	USG I-3765-85

850 W. Bartlett Rd. / Bartlett, IL 60103-4400 / 630-289-3100 / Fax: 630-289-5445 / 800-378-5700

TestAmerica
INCORPORATED

ANALYTICAL REPORT

Mr. Chris Barden
HARZA ENGINEERING COMPANY
233 S. Wacker Drive
Chicago, IL 60606

03/28/2000

Sample No. : 571750

Job No.: 00.02692

Sample Description: CL-4
Cedar Lake - Proj. #15825.B.300

Date Taken: 03/20/2000
Time Taken: 10:45

Date Received: 03/20/2000
Time Received: 16:35

Parameter	Result	Flag	Units	Reporting Limit	Date Analyzed	Analyst Initials	Analytical Method
BOD, Five Day	<4		mg/L	2	03/21/2000	mpe	SM 5210B
N-Ammonia	<0.50		mg/L	0.50	03/22/2000	jrr	EPA 350.1
Nitrate + Nitrite	2.7		mg/L	1.0	03/27/2000	aks	SM 4500NO3
Phosphate, Ortho	0.31		mg/L	0.06	03/21/2000	jrr	EPA 365.2
Phosphorus, Total	0.14		mg/L	0.02	03/28/2000	jrr	SM 4500P E
Solids, Total Suspended	18		mg/L	5	03/27/2000	aks	USG I-3765-85

850 W. Bartlett Rd. / Bartlett, IL 60103-4400 / 630-289-3100 / Fax: 630-289-5445 / 800-378-5700

TestAmerica
INCORPORATED

ANALYTICAL REPORT

Mr. Chris Barden
HARZA ENGINEERING COMPANY
233 S. Wacker Drive
Chicago, IL 60606

03/28/2000

Sample No. : 571751

Job No.: 00.02692

Sample Description: CL-5
Cedar Lake - Proj. #15825.B.300

Date Taken: 03/20/2000
Time Taken: 10:50

Date Received: 03/20/2000
Time Received: 16:35

Parameter	Result	Flag	Units	Reporting Limit	Date Analyzed	Analyst Initials	Analytical Method
BOD, Five Day	<4		mg/L	2	03/21/2000	mpe	SM 5210B
N-Ammonia	<0.50		mg/L	0.50	03/22/2000	jrr	EPA 350.1
Nitrate + Nitrite	1.5		mg/L	1.0	03/27/2000	aks	SM 4500NO3
Phosphate, Ortho	0.13		mg/L	0.06	03/21/2000	jrr	EPA 365.2
Phosphorus, Total	0.09		mg/L	0.02	03/28/2000	jrr	SM 4500P E
Solids, Total Suspended	13		mg/L	5	03/27/2000	aks	USG I-3765-85

850 W. Bartlett Rd. / Bartlett, IL 60103-4400 / 630-289-3100 / Fax: 630-289-5445 / 800-378-5700

KEY TO ABBREVIATIONS and METHOD REFERENCES

<	:	Less than; When appearing in the results column indicates the analyte was not detected at or above the reported value.
mg/L	:	Concentration in units of milligrams of analyte per liter of sample. Measurement used for aqueous samples. Can also be expressed as parts per million (ppm).
ug/g	:	Concentration in units of micrograms of analyte per gram of sample. Measurement used for non-aqueous samples. Can also be expressed as parts per million (ppm) or mg/Kg.
ug/L	:	Concentration in units of micrograms of analyte per liter of sample. Measurement used for aqueous samples. Can also be expressed as parts per billion (ppb).
ug/Kg	:	Concentration in units of micrograms of analyte per kilogram of sample. Measurement used for non-aqueous samples. Can also be expressed as parts per billion (ppb).
TCLP	:	These initials appearing in front of an analyte name indicate that the Toxicity Characteristic Leaching Procedure (TCLP) was performed for this test.
Surr:	:	These initials are the abbreviation for surrogate. Surrogates are compounds that are chemically similar to the compounds of interest. They are part of the method quality control requirements.
%	:	Percent; To convert ppm to %, divide the result by 10,000. To convert % to ppm, multiply the result by 10,000.
ICP	:	Indicates analysis was performed using Inductively Coupled Plasma Spectroscopy.
AA	:	Indicates analysis was performed using Atomic Absorption Spectroscopy.
GFAA	:	Indicates analysis was performed using Graphite Furnace Atomic Absorption Spectroscopy.
PQL	:	Practical Quantitation Limit; the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions.

Method References

(1) Methods 1000 through 9999: see "Test Methods for Evaluating Solid Waste", USEPA SW-846, 3rd Edition, 1986.

(2) ASTM "American Society for Testing Materials"

(3) Methods 100 through 499: see "Methods for Chemical Analysis of Water and Wastes", USEPA, 600/4-79-020, Rev. 1983.

(4) See "Standard Methods for the Examination of Water and Wastewater", 17th Ed, APHA, 1989.

(5) Methods 600 through 625: see "Guidelines Establishing Test Procedures for the Analysis of Pollutants", USEPA Federal Register Vol. 49 No. 209, October 1984.

(6) Methods 500 through 599: see "Methods for the Determination of Organic Compounds in Drinking Water," USEPA 600/4-88/039, Rev. 1988.

(7) See "Methods for the Determination of Metals in Environmental Samples", Supplement I EPA-600/R-94/111, May 1994.

(8) See "Standard Methods for the Examination of Water and Wastewater", 18th Ed., APHA, 1992.

(9) Methods 1000 through 9999: see "Test Methods for Evaluating Solid Waste", USEPA SW-846, 3rd Edition, 1986, Including Updates I and II.

(10) This method is from the 2nd Edition of "Test Methods for Evaluating Solid Waste", USEPA SW-846. It has been dropped from the 3rd Edition, 1986.

HARZA Consulting Engineers and Scientists

SEARS TOWER • 233 South Wacker Drive • Chicago, Illinois 60606-6392 Tel: (312) 831-3800 • Fax: (312) 831-3999 • Telex: 25-3540

No 1029

CHAIN OF CUSTODY RECORD

SITE: Cedar Lake

SAMPLER: (Signature) Chris Bard

PROJECT No. 15925.B.300

PARAMETERS

COOLER No.

FIELD SAMPLE NUMBER	DATE	TIME	COMP.	GRAB	STATION LOCATION	No. OF CONTAINERS	Ortho P	TSS	Ammonia	Nitrate	BOD5	Total P				REMARKS
CL-1	3-20	1000		✓	North Inlet	4	X	X	X	X	X	X				#10
CL-2	3-20	1005		✓	Old Bank Building	4	X	X	X	X	X	X				#11
CL-3	3-20	1010		✓	Golf Course	4	X	X	X	X	X	X				Looking Glass Label #12
CL-4	3-20	1045		✓		4	X	X	X	X	X	X				#13
CL-5	3-20	10:50		✓		4	X	X	X	X	X	X				#14

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Relinquished by: (Signature)	Date	Time	Received by: (Signature)
Chris Bard	3-20-00	15:00	Joe Ian... #55		3/20/00	1635	K. Waldt

3°C wet ice

Relinquished by: (Signature)	Date	Time	Received for Laboratory by: (Signature)	Date	Time	Remarks:

NORTHLAND Laboratories Dedicated to Quality Testing for the Food and Allied Industries Since 1949

Northbrook Division, Corporate Office
1818 Skokie Blvd. Northbrook, IL 60062
(847)272-8700 Fax: (847) 272-2348

Analytical Test Report

HARZA ENGINEERING COMPANY 233 SOUTH WACKER DR CHICAGO, IL. 60606 ATTN: DOUG MULVEY	ACCOUNT : 1063 COPY : 1 DATE : 03/22/2000
LAB IDEE # : 10320990907 SAMPLE CODE : CL1 LOT NUMBER : WATER DATE RECEIVED: 03/20/2000 P.O. NUMBER : 1030 SUBMITTER : DOUG MULVEY REQUEST # : IL DPH #17581	DESCRIPTION: 3:20 11:00 NORTH INLET #15825 B.300

TEST NAME/METHODOLOGY	RESULT	UNITS
E. COLI COUNT (VRBA) Method: FDA APHA AND BAM	70	COLONY FORMING UNITS PER GRAM
FAXED REPORT Method: TRANSMISSION	COMPLETED 03/22/2000.	

Reviewed By: Edward Cort

-END OF REPORT-

Certification Number:	IL DPH #17581 USDA/FSIS - Salmonella & Listeria #0164 USDA/FSIS - Chemistry #1761

NORTHLAND Laboratories Dedicated to Quality Testing for the Food and Allied Industries Since 1949

Northbrook Division, Corporate Office
1818 Skokie Blvd. Northbrook, IL 60062
(847)272-8700 Fax: (847) 272-2348

Analytical Test Report

HARZA ENGINEERING COMPANY
233 SOUTH WACKER DR
CHICAGO, IL. 60606
ATTN: DOUG MULVEY

ACCOUNT : 1063
COPY : 1
DATE : 03/22/2000

LAB IDEE # : 10320990908
SAMPLE CODE : CL2
LOT NUMBER : WATER
DATE RECEIVED: 03/20/2000
P.O. NUMBER : 1030
SUBMITTER : DOUG MULVEY

REQUEST # : IL DPH #17581

DESCRIPTION: 3-20 11:05 OLD BANK BUILDING #15825
B.300

TEST NAME/METHODOLOGY	RESULT	UNITS
E. COLI COUNT (VRBA) Method: FDA APHA AND BAM	270	COLONY FORMING UNITS PER GRAM
FAXED REPORT Method: TRANSMISSION	COMPLETED 03/22/2000.	

Reviewed By: Edward Cork

-END OF REPORT-

Certification Number:	IL DPH #17581 USDA/FSIS - Salmonella & Listeria #0164 USDA/FSIS - Chemistry #1761

NORTHLAND Laboratories Dedicated to Quality Testing for the Food and Allied Industries Since 1949

Northbrook Division, Corporate Office
1818 Skokie Blvd. Northbrook, IL 60062
(847)272-8700 Fax: (847) 272-2348

Analytical Test Report

HARZA ENGINEERING COMPANY
233 SOUTH WACKER DR
CHICAGO, IL. 60606
ATTN: DOUG MULVEY

ACCOUNT : 1063
COPY : 1
DATE : 03/22/2000

LAB IDEE # : 10320990909
SAMPLE CODE : CL3
LOT NUMBER : WATER
DATE RECEIVED: 03/20/2000
P.O. NUMBER : 1030
SUBMITTER : DOUG MULVEY

REQUEST # : IL DPH #17581

DESCRIPTION: 3-20 11:10 GOLF COURSE #15825 B.300

TEST NAME/METHODOLOGY	RESULT	UNITS
E. COLI COUNT (VRBA) Method: FDA APHA AND BAM	130	COLONY FORMING UNITS PER GRAM
FAXED REPORT Method: TRANSMISSION	COMPLETED 03/22/2000.	

Reviewed By: E. Lund Cort

Certification Number: IL DPH #17581
USDA/FSIS - Salmonella & Listeria #0164
USDA/FSIS - Chemistry #1761

-END OF REPORT-

NORTHLAND Laboratories Dedicated to Quality Testing for the Food and Allied Industries Since 1948

Northbrook Division, Corporate Office
1818 Skokie Blvd. Northbrook, IL 60062
(847)272-8700 Fax: (847) 272-2348

Analytical Test Report

HARZA ENGINEERING COMPANY 233 SOUTH WACKER DR CHICAGO, IL. 60606 ATTN: DOUG MULVEY	ACCOUNT : 1063 COPY : 1 DATE : 03/22/2000
LAB IDEE # : 10320990910 SAMPLE CODE : CL4 LOT NUMBER : WATER DATE RECEIVED: 03/20/2000 P.O. NUMBER : 1030 SUBMITTER : DOUG MULVEY REQUEST # : IL DPH #17581	DESCRIPTION: 3-20 WATER #15825 B.300

TEST NAME/METHODOLOGY	RESULT	UNITS
E. COLI COUNT (VRBA) Method: FDA APHA AND BAM	360	COLONY FORMING UNITS PER GRAM
FAXED REPORT Method: TRANSMISSION	COMPLETED 03/22/2000.	

Reviewed By: Edward Cox

-END OF REPORT-

Certification Number:	IL DPH #17581 USDA/FSIS - Salmonella & Listeria #0164 USDA/FSIS - Chemistry #1761

NORTHLAND Laboratories Dedicated to Quality Testing for the Food and Allied Industries Since 1949

Northbrook Division, Corporate Office
1818 Skokie Blvd. Northbrook, IL 60062
(847)272-8700 Fax: (847) 272-2348

Analytical Test Report

HARZA ENGINEERING COMPANY
233 SOUTH WACKER DR
CHICAGO, IL. 60606
ATTN: DOUG MULVEY

ACCOUNT : 1063
COPY : 1
DATE : 03/22/2000

LAB IDEE # : 10320990911
SAMPLE CODE : CL5
LOT NUMBER : WATER
DATE RECEIVED: 03/20/2000
P.O. NUMBER : 1030
SUBMITTER : DOUG MULVEY

REQUEST # : IL DPH #17581

DESCRIPTION: 3-20 10:50 WATER #15825 B-300

TEST NAME/METHODOLOGY	RESULT	UNITS
E. COLI COUNT (VRBA) Method: FDA APHA AND BAM	270	COLONY FORMING UNITS PER GRAM
FAXED REPORT Method: TRANSMISSION	COMPLETED 03/22/2000.	

Reviewed By: Edward Conl

-END OF REPORT-

Certification Number: IL DPH #17581
USDA/FSIS - Salmonella & Listeria #0164
USDA/FSIS - Chemistry #1761

TestAmerica
INCORPORATED

Mr. Doug Mulvey
HARZA ENGINEERING COMPANY
233 S. Wacker Drive
Chicago, IL 60606

05/22/2000

Job Number: 00.04937

IEPA Cert. No.: 100221
WDNR Cert. No.: 999447130

Enclosed is the Analytical and Quality Control reports for the following samples submitted to Bartlett Division of TestAmerica for analysis.

Project Description: Cedar Lake

Sample Number	Sample Description	Date Taken	Date Received
579959	CL-1	05/12/2000	05/12/2000
579960	CL-2	05/12/2000	05/12/2000
579961	CL-3	05/12/2000	05/12/2000
579962	CL-4	05/12/2000	05/12/2000
579963	CL-5	05/12/2000	05/12/2000

Sample analysis in support of the project referenced above has been completed and results are presented on the following pages. These results apply only to the samples analyzed. Reproduction of this report only in whole is permitted. Please refer to the enclosed "Key to Abbreviations" for definition of terms. Procedures used follow TestAmerica Standard Operating Procedures which reference the methods listed on your report. Should you have questions regarding procedures or results, please do not hesitate to call. TestAmerica has been pleased to provide these analytical services for you.

This Quality Control report is generated on a batch basis. All information contained in this report is for the analytical batch(es) in which your sample(s) were analyzed.

Approved by:

Mary Pearson

Mary Pearson
Project Manager

TestAmerica
INCORPORATED

ANALYTICAL REPORT

Mr. Doug Mulvey
HARZA ENGINEERING COMPANY
233 S. Wacker Drive
Chicago, IL 60606

05/22/2000

Sample No. : 579959

Job No.: 00.04937

Sample Description: CL-1
Cedar Lake

Date Taken: 05/12/2000
Time Taken: 09:15

Date Received: 05/12/2000
Time Received: 16:38

Parameter	Result	Flag	Units	Reporting Limit	Date Analyzed	Analyst Initials	Analytical Method
BOD, Five Day	<4		mg/L	2	05/12/2000	mpe	SM 5210B
N-Ammonia	2.0		mg/L	0.50	05/15/2000	jrr	EPA 350.1
N-Kjeldahl	2.9		mg/L	0.50	05/19/2000	jrr	EPA 351.2
N-Nitrate	<1.0		mg/L	1.0	05/13/2000	aks	SM 4500NO3
Phosphorus, ortho	0.07		mg/L	0.02	05/12/2000	jrr	SM 4500P-E
Phosphorus, Total	0.38		mg/L	0.02	05/22/2000	jrr	SM 4500P E
Solids, Total Suspended	78		mg/L	5	05/19/2000	lmf	EPA 160.2

850 W. Bartlett Rd. / Bartlett, IL 60103-4400 / 630-289-3100 / Fax: 630-289-5445 / 800-378-5700

TestAmerica
INCORPORATED

ANALYTICAL REPORT

Mr. Doug Mulvey
HARZA ENGINEERING COMPANY
233 S. Wacker Drive
Chicago, IL 60606

05/22/2000

Sample No. : 579960

Job No.: 00.04937

Sample Description: CL-2
Cedar Lake

Date Taken: 05/12/2000
Time Taken: 08:45

Date Received: 05/12/2000
Time Received: 16:38

Parameter	Result	Flag	Units	Reporting Limit	Date Analyzed	Analyst Initials	Analytical Method
BOD, Five Day	6		mg/L	2	05/12/2000	mpe	SM 5210B
N-Ammonia	<0.50		mg/L	0.50	05/15/2000	jrr	EPA 350.1
N-Kjeldahl	1.4		mg/L	0.50	05/19/2000	jrr	EPA 351.2
N-Nitrate	<1.0		mg/L	1.0	05/13/2000	aks	SM 4500NO3
Phosphorus, ortho	0.05		mg/L	0.02	05/12/2000	jrr	SM 4500P-E
Phosphorus, Total	0.18		mg/L	0.02	05/22/2000	jrr	SM 4500P E
Solids, Total Suspended	140		mg/L	5	05/19/2000	lmf	EPA 160.2

850 W. Bartlett Rd. / Bartlett, IL 60103-4400 / 630-289-3100 / Fax: 630-289-5445 / 800-378-5700

TestAmerica
INCORPORATED

ANALYTICAL REPORT

Mr. Doug Mulvey
HARZA ENGINEERING COMPANY
233 S. Wacker Drive
Chicago, IL 60606

05/22/2000

Sample No. : 579961

Job No.: 00.04937

Sample Description: CL-3
Cedar Lake

Date Taken: 05/12/2000
Time Taken: 08:30

Date Received: 05/12/2000
Time Received: 16:38

Parameter	Result	Flag	Units	Reporting Limit	Date Analyzed	Analyst Initials	Analytical Method
BOD, Five Day	20		mg/L	2	05/12/2000	mpe	SM 5210B
N-Ammonia	<0.50		mg/L	0.50	05/15/2000	jrr	EPA 350.1
N-Kjeldahl	4.8		mg/L	0.50	05/19/2000	jrr	EPA 351.2
N-Nitrate	<1.0		mg/L	1.0	05/13/2000	aks	SM 4500NO3
Phosphorus, ortho	0.02		mg/L	0.02	05/12/2000	jrr	SM 4500P-E
Phosphorus, Total	0.18		mg/L	0.02	05/22/2000	jrr	SM 4500P E
Solids, Total Suspended	40		mg/L	5	05/19/2000	lmf	EPA 160.2

850 W. Bartlett Rd. / Bartlett, IL 60103-4400 / 630-289-3100 / Fax: 630-289-5445 / 800-378-5700

TestAmerica
INCORPORATED

ANALYTICAL REPORT

Mr. Doug Mulvey
HARZA ENGINEERING COMPANY
233 S. Wacker Drive
Chicago, IL 60606

05/22/2000

Sample No. : 579962

Job No.: 00.04937

Sample Description: CL-4
Cedar Lake

Date Taken: 05/12/2000
Time Taken: 09:45

Date Received: 05/12/2000
Time Received: 16:38

Parameter	Result	Flag	Units	Reporting Limit	Date Analyzed	Analyst Initials	Analytical Method
BOD, Five Day	<4		mg/L	2	05/12/2000	mpe	SM 5210B
N-Ammonia	<0.50		mg/L	0.50	05/15/2000	jrr	EPA 350.1
N-Kjeldahl	1.0		mg/L	0.50	05/19/2000	jrr	EPA 351.2
N-Nitrate	<1.0		mg/L	1.0	05/13/2000	aks	SM 4500NO3
Phosphorus, ortho	0.07		mg/L	0.02	05/12/2000	jrr	SM 4500P-E
Phosphorus, Total	0.13		mg/L	0.02	05/22/2000	jrr	SM 4500P E
Solids, Total Suspended	99		mg/L	5	05/19/2000	lmf	EPA 160.2

850 W. Bartlett Rd. / Bartlett, IL 60103-4400 / 630-289-3100 / Fax: 630-289-5445 / 800-378-5700

TestAmerica INCORPORATED

ANALYTICAL REPORT

Mr. Doug Mulvey
HARZA ENGINEERING COMPANY
233 S. Wacker Drive
Chicago, IL 60606

05/22/2000

Sample No. : 579963

Job No.: 00.04937

Sample Description: CL-5
Cedar Lake

Date Taken: 05/12/2000
Time Taken: 09:30

Date Received: 05/12/2000
Time Received: 16:38

Parameter	Result	Flag	Units	Reporting Limit	Date Analyzed	Analyst Initials	Analytical Method
BOD, Five Day	<4		mg/L	2	05/12/2000	mpe	SM 5210B
N-Ammonia	<0.50		mg/L	0.50	05/15/2000	jrr	EPA 350.1
N-Kjeldahl	0.91		mg/L	0.50	05/19/2000	jrr	EPA 351.2
N-Nitrate	1.1		mg/L	1.0	05/13/2000	aks	SM 4500NO3
Phosphorus, ortho	0.06		mg/L	0.02	05/12/2000	jrr	SM 4500P-E
Phosphorus, Total	0.10		mg/L	0.02	05/22/2000	jrr	SM 4500P E
Solids, Total Suspended	8		mg/L	5	05/19/2000	lmf	EPA 160.2

850 W. Bartlett Rd. / Bartlett, IL 60103-4400 / 630-289-3100 / Fax: 630-289-5445 / 800-378-5700

TestAmerica INCORPORATED

TestAmerica, Bartlett Division

KEY TO ABBREVIATIONS and METHOD REFERENCES

<	:	Less than; When appearing in the results column indicates the analyte was not detected at or above the reported value.
mg/L	:	Concentration in units of milligrams of analyte per liter of sample. Measurement used for aqueous samples. Can also be expressed as parts per million (ppm).
ug/g	:	Concentration in units of micrograms of analyte per gram of sample. Measurement used for non-aqueous samples. Can also be expressed as parts per million (ppm) or mg/Kg.
ug/L	:	Concentration in units of micrograms of analyte per liter of sample. Measurement used for aqueous samples. Can also be expressed as parts per billion (ppb).
ug/Kg	:	Concentration in units of micrograms of analyte per kilogram of sample. Measurement used for non-aqueous samples. Can also be expressed as parts per billion (ppb).
TCLP	:	These initials appearing in front of an analyte name indicate that the Toxicity Characteristic Leaching Procedure (TCLP) was performed for this test.
Surr:	:	These initials are the abbreviation for surrogate. Surrogates are compounds that are chemically similar to the compounds of interest. They are part of the method quality control requirements.
%	:	Percent; To convert ppm to %, divide the result by 10,000. To convert % to ppm, multiply the result by 10,000.
ICP	:	Indicates analysis was performed using Inductively Coupled Plasma Spectroscopy.
AA	:	Indicates analysis was performed using Atomic Absorption Spectroscopy.
GFAA	:	Indicates analysis was performed using Graphite Furnace Atomic Absorption Spectroscopy.
PQL	:	Practical Quantitation Limit; the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions.

Method References

(1) Methods 1000 through 9999: see "Test Methods for Evaluating Solid Waste", USEPA SW-846, 3rd Edition, 1986.

(2) ASTM "American Society for Testing Materials"

(3) Methods 100 through 499: see "Methods for Chemical Analysis of Water and Wastes", USEPA, 600/4-79-020, Rev. 1983.

(4) See "Standard Methods for the Examination of Water and Wastewater", 17th Ed, APHA, 1989.

(5) Methods 600 through 625: see "Guidelines Establishing Test Procedures for the Analysis of Pollutants", USEPA Federal Register Vol. 49 No. 209, October 1984.

(6) Methods 500 through 599: see "Methods for the Determination of Organic Compounds in Drinking Water," USEPA 600/4-88/039, Rev. 1988.

(7) See "Methods for the Determination of Metals in Environmental Samples", Supplement I EPA-600/R-94/111, May 1994.

(8) See "Standard Methods for the Examination of Water and Wastewater", 18th Ed., APHA, 1992.

(9) Methods 1000 through 9999: see "Test Methods for Evaluating Solid Waste", USEPA SW-846, 3rd Edition, 1986, Including Updates I and II.

(10) This method is from the 2nd Edition of "Test Methods for Evaluating Solid Waste", USEPA SW-846. It has been dropped from the 3rd Edition, 1986.

850 W. Bartlett Rd. / Bartlett, IL 60103-4400 / 630-289-3100 / Fax: 630-289-5445 / 800-378-5700

HARZA *Consulting Engineers and Scientists*

No 1059

SEARS TOWER • 233 South Wacker Drive • Chicago, Illinois 60606-6392 Tel: (312) 831-3800 • Fax: (312) 831-3999 • Telex: 25-3540

MAY-23-2000 08:39

CHAIN OF CUSTODY RECORD

SITE: CEDAR LAKE

COOLER No.

SAMPLER: (Signature) Douglas Mulroy

PROJECT No.

PARAMETERS

FIELD SAMPLE NUMBER	DATE	TIME	COMP.	GRAB	STATION LOCATION	No. OF CONTAINERS	BOD, NO_3, TSS - 960ml Plastic	NH_3, TKN - 960ml Plastic w/ H_2SO_4	Ortho P - Amber Glass	Total P - Amber Glass w/ H_2SO_4	REMARKS
CL-1	5/12/00	0915		x	Chamber of Commerce	4	✓	✓	✓	✓	Cold, 4°C
CL-2	↓	0845		x	Bank Building	4	✓	✓	✓	✓	↓
CL-3	↓	0830		x	Golf Course	4	✓	✓	✓	✓	↓
CL-4	↓	0945		x	Northpoint	4	✓	✓	✓	✓	↓
CL-5	↓	0930		x	Condo	4	✓	✓	✓	✓	↓

DLM

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Relinquished by: (Signature)	Date	Time	Received by: (Signature)
Douglas Mulroy	5/12/00	1638					

Relinquished by: (Signature)	Date	Time	Received for Laboratory by: (Signature)	Date	Time	Remarks:
			R. Walton	5/12/00	1638	Rec'd on ice 2.2°C

BARTLETT LHB

TOTAL P.08

NORTHLAND Laboratories Dedicated to Quality Testing for the Food and Allied Industries Since 1949

Northbrook Division, Corporate Office
1818 Skokie Blvd. Northbrook, IL 60062
(847)272-8700 Fax: (847) 272-2348

Analytical Test Report

HARZA ENGINEERING COMPANY
233 SOUTH WACKER DR
CHICAGO, IL. 60606
ATTN: DOUG MULVEY

ACCOUNT : 1063
COPY : 1
DATE : 05/18/2000

LAB IDEE # : 10512990664
SAMPLE CODE : 5/12/00
LOT NUMBER : 0915
DATE RECEIVED: 05/12/2000
P.O. NUMBER : 1060
SUBMITTER : DOUG MULVEY

REQUEST # : IL DPH #17581

DESCRIPTION: CL-1 - CHAMBER OF COMMERCE - PROJECT #15825B

TEST NAME/METHODOLOGY	RESULT	UNITS
E. COLI COUNT (MPN) Method: FDA APHA AND BAM	93	COLONY FORMING UNITS PER GRAM
FAXED REPORT Method: TRANSMISSION		

Reviewed By:______________________________

-END OF REPORT-

Certification Number: IL DPH #17581
USDA/FSIS - Salmonella & Listeria #0164
USDA/FSIS - Chemistry #1761

NORTHLAND Laboratories
Dedicated to Quality Testing for the Food and Allied Industries Since 1949

Northbrook Division, Corporate Office
1818 Skokie Blvd. Northbrook, IL 60062
(847)272-8700 Fax: (847) 272-2348

Analytical Test Report

HARZA ENGINEERING COMPANY
233 SOUTH WACKER DR
CHICAGO, IL. 60606
ATTN: DOUG MULVEY

ACCOUNT : 1063
COPY : 1
DATE : 05/18/2000

LAB IDEE # : 10512990665
SAMPLE CODE : 5/12/00
LOT NUMBER : 0845
DATE RECEIVED: 05/12/2000
P.O. NUMBER : 1060
SUBMITTER : DOUG MULVEY

REQUEST # : IL DPH #17581

DESCRIPTION: CL-2 - BANK BUILDING - PROJECT #15825B

TEST NAME/METHODOLOGY	RESULT	UNITS
E. COLI COUNT (MPN) Method: FDA APHA AND BAM	93	COLONY FORMING UNITS PER GRAM
FAXED REPORT Method: TRANSMISSION		

Certification Number: IL DPH #17581
USDA/FSIS - Salmonella & Listeria #0164
USDA/FSIS - Chemistry #1761

Reviewed By:______________________________

-END OF REPORT-

NORTHLAND Laboratories Dedicated to Quality Testing for the Food and Allied Industries Since 1949

Northbrook Division, Corporate Office
1818 Skokie Blvd. Northbrook, IL 60062
(847)272-8700 Fax: (847) 272-2348

Analytical Test Report

HARZA ENGINEERING COMPANY
233 SOUTH WACKER DR
CHICAGO, IL. 60606
ATTN: DOUG MULVEY

ACCOUNT : 1063
COPY : 1
DATE : 05/18/2000

LAB IDEE # : 10512990666
SAMPLE CODE : 5/12/00
LOT NUMBER : 0830
DATE RECEIVED: 05/12/2000
P.O. NUMBER : 1060
SUBMITTER : DOUG MULVEY

REQUEST # : IL DPH #17581

DESCRIPTION: CL-3 - GOLF COURSE - PROJECT #15825B

TEST NAME/METHODOLOGY	RESULT	UNITS
E. COLI COUNT (MPN) Method: FDA APHA AND BAM	460	COLONY FORMING UNITS PER GRAM
FAXED REPORT Method: TRANSMISSION		

Certification Number:	IL DPH #17581 USDA/FSIS - Salmonella & Listeria #0164 USDA/FSIS - Chemistry #1761

Reviewed By:____________________

-END OF REPORT-

NORTHLAND Laboratories Dedicated to Quality Testing for the Food and Allied Industries Since 1949

Northbrook Division, Corporate Office
1818 Skokie Blvd. Northbrook, IL 60062
(847)272-8700 Fax: (847) 272-2348

Analytical Test Report

HARZA ENGINEERING COMPANY
233 SOUTH WACKER DR
CHICAGO, IL. 60606
ATTN: DOUG MULVEY

ACCOUNT : 1063
COPY : 1
DATE : 05/18/2000

LAB IDEE # : 10512990667
SAMPLE CODE : 5/12/00
LOT NUMBER : 0945
DATE RECEIVED: 05/12/2000
P.O. NUMBER : 1060
SUBMITTER : DOUG MULVEY

REQUEST # : IL DPH #17581

DESCRIPTION: CL-4 - NORTHPOINT - PROJECT #15825B

TEST NAME/METHODOLOGY	RESULT	UNITS
E. COLI COUNT (MPN) Method: FDA APHA AND BAM	<3.0	COLONY FORMING UNITS PER GRAM
FAXED REPORT Method: TRANSMISSION		

Certification Number: IL DPH #17581
USDA/FSIS - Salmonella & Listeria #0164
USDA/FSIS - Chemistry #1761

Reviewed By:____________________

-END OF REPORT-

NORTHLAND Laboratories Dedicated to Quality Testing for the Food and Allied Industries Since 1949

Northbrook Division, Corporate Office
1818 Skokie Blvd. Northbrook, IL 60062
(847)272-8700 Fax: (847) 272-2348

Analytical Test Report

HARZA ENGINEERING COMPANY
233 SOUTH WACKER DR
CHICAGO, IL. 60606
ATTN: DOUG MULVEY

ACCOUNT : 1063
COPY : 1
DATE : 05/18/2000

LAB IDEE # : 10512990668
SAMPLE CODE : 5/12/00
LOT NUMBER : 0930
DATE RECEIVED: 05/12/2000
P.O. NUMBER : 1060
SUBMITTER : DOUG MULVEY

REQUEST # : IL DPH #17581

DESCRIPTION: CL-5 - CONDO - PROJECT #15825B

TEST NAME/METHODOLOGY	RESULT	UNITS
E. COLI COUNT (MPN) Method: FDA APHA AND BAM	93	COLONY FORMING UNITS PER GRAM
FAXED REPORT Method: TRANSMISSION		

Certification Number: IL DPH #17581
USDA/FSIS - Salmonella & Listeria #0164
USDA/FSIS - Chemistry #1761

Reviewed By:______________________________

-END OF REPORT-

APPENDIX C

FIELD SAMPLE COLLECTION SHEET

Project Name: CEDAR LAKE Diagnostic FS

Date: 5/12/00

Project No: 15825B.300

Time: 0915

Name of Drain and Subdrain: Chamber of Commerce

Sample Round: 3

Sample Location: CL-1

Sample No: CL-1

Sample/Media Type: Water Sediment Sludge Wastewater Other: ______

Sample Split (circle one) Yes No

Split Sample No: ______

Duplicate Sample (circle one) Yes No

Duplicate Sample No: ______

Sampling Personnel: DLM

Equipment Used: picture 2

Visual Site Assessment: stagnant flow, lots of H_2O in wetland, floating algae, floating foam like @ WWTP on south side

In-Situ Parameters: Sample taken on N side of road parameters measured on the south

Parameter	Measurement	Parameter	Measurement
Water Temperature (°C)	19.5	Turbidity (NTU)	7
Sample Depth [redacted] (ft)	6''		
pH	4.12		
Dissolved Oxygen (mg/L)	1.3		
Oxidation/Reduction Potential (mV)			
Specific Conductivity (µS/cm)	1.04		

DO reading suspect because of ~~very low~~ no flow ~~flow and~~ and shallow conditions

FIELD SAMPLE COLLECTION SHEET

Project Name: CEDAR LAKE Diagnostic FS

Date: 5/12/00

Project No: 15825B.300

Time: 0845

Name of Drain and Subdrain: Bank Bldg

Sample Round: 3

Sample Location: CL-2

Sample No: CL-2

Sample/Media Type: Water Sediment Sludge Wastewater Other: ______

Sample Split (circle one) Yes No

Split Sample No: ______

Duplicate Sample (circle one) Yes No

Duplicate Sample No: ______

Sampling Personnel: ______

Equipment Used: pic /, very low flow max 0.5 L/s

Visual Site Assessment: ______

In-Situ Parameters

Parameter	Measurement	Parameter	Measurement
Water Temperature (°C)	16.5	Turbidity (NTU)	10
Sample Depth [redacted] (ft)	1''		
pH	4.2		
Dissolved Oxygen (mg/L)	7.4		
Oxidation/Reduction Potential (mV)			
Specific Conductivity (mS/cm)	1.15		

FIELD SAMPLE COLLECTION SHEET

Project Name:	CEDAR LAKE Diagnostic FS	Date:	5/12/00
Project No:	15825B.300	Time:	0830
Name of Drain and Subdrain:	Golf Course	Sample Round:	3
Sample Location:	CL-3	Sample No:	CL-3

Sample/Media Type: Water Sediment Sludge Wastewater Other: ____

Sample Split (circle one) Yes No Split Sample No: ____

Duplicate Sample (circle one) Yes No Duplicate Sample No: ____

Sampling Personnel: DLM

Equipment Used: Horiba

Visual Site Assessment: Algae picture

In-Situ Parameters

Parameter	Measurement	Parameter	Measurement
Water Temperature (°C)	19.2	Turbidity (NTU)	40
Sample Depth (ft)	0.5		
pH	4.2		
Dissolved Oxygen (mg/L)	5.1		
Oxidation/Reduction Potential (mV)			
Specific Conductivity (mS/cm)	.415		

FIELD SAMPLE COLLECTION SHEET

Project Name: CEDAR LAKE Diagnostic FS

Date: 5/12/00

Project No: 15825B.300

Time: 0945

Name of Drain and Subdrain: Northpoint MARINA

Sample Round: 3

Sample Location: CL-4

Sample No: CL-4

Sample/Media Type: Water Sediment Sludge Wastewater Other: ______

Sample Split (circle one) Yes No

Split Sample No: ______

Duplicate Sample (circle one) Yes No

Duplicate Sample No: ______

Sampling Personnel: ______

Equipment Used ______

Visual Site Assessment: ______

In-Situ Parameters

Parameter	Measurement	Parameter	Measurement
Water Temperature (°C)	19	Turbidity (NTU)	7
Sample Depth [redacted] (ft)	4"		
pH	4.19		
Dissolved Oxygen (mg/L)	8.7		
Oxidation/Reduction Potential (mV)			
Specific Conductivity (µS/cm)	1.12		

Location

N 41° 22.638

W 87 26.564

FIELD SAMPLE COLLECTION SHEET

Project Name: Cedar Lake Diagnostic FS

Date: 5/12/00

Project No: 15825B.300

Time: 0930

Name of Drain and Subdrain: Condo Inlet

Sample Round: 3

Sample Location: CL-5

Sample No: CL-5

Sample/Media Type: Water Sediment Sludge Wastewater Other: ______

Sample Split (circle one) Yes No

Split Sample No: ______

Duplicate Sample (circle one) Yes No

Duplicate Sample No: ______

Sampling Personnel: DLM

Equipment Used ______

Visual Site Assessment: Stagnant flow about 6" deep, steep bank w/ erosion evidence
3 pictures

In-Situ Parameters

Parameter	Measurement	Parameter	Measurement
Water Temperature (°C)	17.3	Turbidity (NTU)	7
Sample Depth [redacted] (ft)	6"		
pH	4.1		
Dissolved Oxygen (mg/L)	6.5		
Oxidation/Reduction Potential (mV)			
Specific Conductivity (mS/cm)	3.19		

Location

N 41°23.099

W 87 25.943

APPENDIX D

APPENDIX D

BEST MANAGEMENT PRACTICES (BMPS)

Best management practices, or BMPs, are restrictions, structures or practices that mitigate the adverse anthropogenic effects on runoff quality and/or quantity. Agricultural BMPs include various types of conservation buffers such as grassed waterways, no-till cropping, and many other structures and practices. Urban BMPs typically include impoundments and nutrient management measures such as reduced application of fertilizer and pesticides. The relative effectiveness of the BMP for reducing storm runoff peaks and volumes, and for addressing pollutants are generalized in the matrix below. Each BMP is subsequently described in more detail.

Table D-1

GENERAL EFFECTIVENESS OF SELECT AGRICULTURAL BMPS

BMP	**Suspended Solids**	**Nitrogen**	**Phosphorus**	**Runoff Volume**
Impoundments				
Dry Detention Ponds	●	●	●	●●●
Wet Detention Ponds	●●●	●●	●●	●●●
WASCOBs				
Wetland Basins	●●●	●●	●●●	●●●
Wetland Channels	●●	●●	●●	●●
Vegetative Filters				
Filter Strips	●●	●	●	●
Grassed Waterways	●●	●	●	●
Land Management Practices				
Residue Management	●●●	●●	●●	●●

Stripcropping	•••	••	••	••
Terracing	•••	••	•••	•••
Nutrient Management	••	•••	•••	••
Others				
Sand Filtration	•••	•	••	•

• = Usually not very effective treatment

••• = Usually very effective treatment

1. SAND FILTERS

Sand filters are a type of stormwater control structure used to treat runoff from buildings, roads, parking lots. Sand filters are also used to treat potable water, industrial process water and agricultural wastewater. Sand filters may be installed underground in trenches or pre-cast concrete boxes or above-ground in beds that can treat stormwater from drainage areas as much as five acres in size.

Sand filters are most common in urban areas and on sites with restricted space. The City of Austin, Texas and the State of Florida have built large, above-ground sand filters. Underground sand filters have been installed in several eastern states. Both versions pre-treatment to remove sediment, floating debris, and oil and grease to protect the filter. As stormwater flows through the filter bed, sediment particles and adsorbed pollutants are captured.

Pollutant removal for sand filters varies depending on the site, climate and loading. Overall removal for sediment and trace metals is better than removal of soluble pollutants. Table D-2 lists removal rates taken from the literature. Unfortunately, due to the large areas requiring treatment in agricultural crop watersheds, sand filters are generally not utilized.

Table D-2

SAND FILTER RELATIVE POLLUTANT REMOVAL EFFICIENCY

(Source: Schueler, *et al.* 1992)

Pollutant	Efficiency
Bacteria	Moderate
Oil and Grease	High
BOD	Moderate
Trace metals (sediment-bound)	Very High
Sediment	Very High
Total Phosphorus	Moderate
Total Nitrogen	Moderate

2. BUFFERS, FILTER STRIPS AND GRASSED WATERWAYS

Vegetation reduces the velocity of stormwater. This improves infiltration and sedimentation, as well as prevents erosion. Vegetation is often part of a BMP system to remove particulates and slow runoff before it enters another treatment device. Buffer strips, filter strips and grassed waterways are described in this section.

The NRCS defines a filter strip as a strip or area of herbaceous vegetation situated between cropland, grazing land, or disturbed land (including forest land) and environmentally sensitive areas. NRCS defines a buffer strip similarly, as a strip or strips of perennial vegetation established in crop fields for wildlife habitat, erosion control, and water quality. Both of these BMPs generally apply in areas situated below cropland, grazing land, or disturbed land where sediment and/or contaminants may leave these areas and are entering environmentally sensitive areas. The NRCS' definition of a grassed waterway is a natural or constructed channel shaped or graded and established in suitable vegetation for the stable conveyance of runoff.

None of these BMPs are part of the adjacent cropland rotation. Overland flow entering filter strips or buffer strips shall be primarily sheet flow. Concentrated flow is dispersed by grading so that the flow is overland, as sheet flow.

Filter strips are typically areas of close-growing vegetation between pollutant sources and receiving waters. They can be used as outlet or pretreatment devices for other stormwater control practices. Filter strips can include shrubs or woody plants that help to stabilize herbaceous and grassy ground cover, or can be composed entirely of trees and other natural vegetation. Filter strips generally do not significantly reduce peak discharges or the volume of storm runoff, but they can be part of a comprehensive BMP system for meeting these needs.

According the NRCS standards, the filter strip should be located along the downslope edge of a field. The average watershed slope above the filter strip should be greater than 0.5% but less than 10%. The average annual sheet and rill erosion rate above the filter strip should be less than 10 tons per acre per year.

Strips should not be less than 20 feet, and protection of some resources may require much wider vegetation strips. Upgradient land slopes greater than 6% should have wider strips, possibly as wide as 130 feet. Floodplain buffer strips having higher flows and longer duration flooding may need to be upwards of 200-feet wide.

Although studies indicate highly varying pollutant removal, trees in strips can be more effective than grass strips alone because of the trees' greater uptake and long-term retention of plant nutrients. Properly constructed forested and grassed filter strips can be expected to remove more than 60 percent of the particulates and perhaps as much as 40 percent of the plant nutrients in urban runoff. Filter strips function best when they are level in the direction of stormwater flow toward the stream. This orientation makes for the finest sheetflow through the strip, increasing infiltration and filtering of sediment and other solids. Filter strips fail if maintenance is irregular.

Grassed swales are waterways vegetated with a dense growth of a hardy grass such as tall fescue or reed canary grass. A grassed waterway/vegetated filter system is a natural or constructed vegetated channel that is shaped and graded to carry surface water at a nonerosive velocity to a stable outlet that spreads the flow of water before it enters a vegetated filter. Grassed waterways and swales are common in agricultural and urban settings.

Minimum capacity for design of grassed waterways is generally intended to confine the peak runoff from a 24-hour, 10-year storm. Waterways may provide some reduction in stormwater pollution through infiltration of runoff water into the soil, filtering of sediment or other solid particles, and slowing the velocity and peak flow rates of runoff. These processes can be enhanced by adding small (4-10 inches high) dams across the swale bottom, thereby increasing detention time.

Pollutants are removed from surface flow by the filtering action of the grass, sediment deposition, and/or infiltration into the soil. The pollutant-removing effectiveness of swales is moderate to negligible depending on many factors, including the quantity of flow, the slope of the swale, the density and height of the grass cover, and the permeability of the underlying soil. Pollutant removal ranges from 30 to 90 percent for sediment and 0 to 40 percent for total phosphorus loads (Table D-3).

Table D-3

VEGETATIVE PRACTICES POLLUTANT REMOVAL EFFICIENCY

(Source: Schueler, 1987, Schueler *et al.* 1992)

Pollutant	Efficiency
Bacteria	Low
Oil and Grease	Moderate
BOD	Low
Trace metals	Moderate
Sediment	Moderate
Total Phosphorus	Low
Total Nitrogen	Low

To be effective, vegetative practices require flat areas that are large in relation to the drainage area, and deep water tables. Swales should have as little slope as possible to maximize infiltration and reduce velocities. Filter strips should not be used where slopes exceed 15 percent, and best performance occurs where the slope is 5% or less. Taller grass will slow velocities more but grass cut to a short length may take up more plant nutrients.

3. CONSTRUCTED WETLANDS

Over the last two decades, interest has increased for the use of natural physical, biological, and chemical aquatic processes for the treatment of polluted waters. Aquatic treatment systems have been divided into natural wetlands, constructed wetlands, and aquatic plant systems (USEPA, 1988). Of the three types, constructed wetlands have received the greatest attention for treatment of nonpoint source pollution. Constructed wetlands are a subset of created wetlands designed and developed specifically for water treatment (Fields, 1993). Constructed wetlands may be developed strictly for mitigation of adverse effects from development on natural wetlands. But, in this context, constructed wetlands serve in a similar capacity as other water quality BMPs, that is, to minimize pollution prior to its entry into streams, lakes and other receiving waters.

Among the most important treatment processes are the purely physical processes of sedimentation, induced by reduced velocities in the wetland. Sedimentation accounts for the relatively high removal rates for suspended solids, the particulate fraction of organic matter and sediment-bound nutrients and metals. Oils and greases are effectively removed through impoundment, photodegradation, and microbial action. Similarly, pathogens show good removal rates in constructed wetlands via sedimentation, natural die-off, and UV degradation. Dissolved constituents such as soluble organic matter, ammonia and ortho-phosphorus tend to have lower removal rates. Soluble organic matter is largely degraded aerobically by bacteria and periphyton. Ammonia is removed through microbial nitrification-denitrification, plant uptake, and volatilization. Nitrate is removed through denitrification and plant uptake. Denitrification is the primary removal mechanism. The microbial degradation processes are relatively slow, particularly the anaerobic denitrification steps, and require longer residence times, a factor which contributes to the variable performance of constructed wetlands systems for dissolved nitrogen. Phosphorus is removed mainly through soil sorption, plant assimilation and burial, processes which are slow and varied. Consequently, phosphorus removal rates are variable and typically trail behind those of nitrogen.

Constructed wetlands can achieve or exceed the pollutant removal rates as estimated for wet pond detention basins and dry detention ponds. General ranges of removal for various pollutants are given below.

Table D-4

CONSTRUCTED WETLAND POLLUTANT REMOVAL EFFICIENCY

(Source: Schueler, 1987, Schueler *et al.* 1992)

Pollutant	**Efficiency**
Bacteria	High
Oil and Grease	Very high
BOD	Moderate
Trace metals (sediment-bound)	High
Sediment	High
Total Phosphorus	High
Total Nitrogen	Moderate

The use of constructed wetlands for stormwater treatment remains an emerging technology and design criteria continue to evolve. General design considerations include the requirement to reduce stormwater inflow velocities and provide opportunity for initial sedimentation. It is important to maximize the hydraulic residence time and the distribution of flow over the treatment area, and to avoid hydraulic short-circuiting. Emergent macrophytes provide substrate for periphyton and are a storage vector for carbon and nutrients. Generally, native emergent vegetation is designed for. Plants must be chosen to withstand the pollutant loading and the frequent fluctuation in water depth.

Constructed wetlands can be a very effective part of a BMP system. Associated features should incorporate minimization of initial runoff volumes; routing of runoff using grassed waterways, swale checks, and other measures; pre-treatment of collected runoff to minimize sediment and associated pollutant loads; and, off-line attenuation of larger storm event runoff to optimize wetland performance and minimize downstream erosion-related water quality impacts.

4. NATURAL AND RESTORED WETLANDS

Natural wetlands also improve water quality. Protection or restoration of wetlands to maintain or enhance water quality is acceptable. However, nonpoint source pollutants should not be intentionally diverted to wetlands for primary treatment. Wetlands should be part of an integrated landscape approach to nonpoint source control, and tied to BMPs in upgradient source areas.

5. WET RETENTION PONDS

Wet retention ponds or basins temporarily detain stormwater. The permanent pool of water enhances the removal of many pollutants. These ponds fill with stormwater and release it slowly. Pollutant removal mechanisms in wet ponds include: sedimentation; biological uptake by plants, algae and bacteria; and, decomposition. Wet ponds have some capacity to remove dissolved nutrients, an important characteristic to protect lakes from eutrophication. Because of the permanent pool, wet ponds can remove moderate to high amounts of most pollutants and are more effective in removing nutrients than most other BMPs.

TABLE D-5

WET DETENTION POND
POLLUTANT REMOVAL EFFICIENCY
(SOURCE: WEF & ASCE, 1998)

Pollutant	Wet Retention Pond	Extended Detention Pond
BOD	20 – 40%	20 – 40%
Zinc	40 – 50%	40 – 50%
Lead	70 – 80%	70 – 80%
Sediment	70 – 80%	70 – 80%
Dissolved Phosphorus	50 – 70%	0
Total Phosphorus	50 – 60%	20 – 50%
Dissolved Nitrogen	50 – 70%	0
Total Nitrogen	30 – 40%	20 – 30%

6. WATER AND SEDIMENT CONTROL BASIN (WASCOB)

Water and sediment control basins, or WASCOBs, are earth embankments or combinations of ridges and channels, generally constructed across the slope and minor watercourses to form a sediment trap and a water detention basin. WASCOBs are a popular BMP, and hundreds have been constructed in Indiana alone. These structures improve the ability to farm sloping land, reduce watercourse and gully erosion, trap sediment, reduce and manage onsite and downstream runoff, and improve downstream water quality.

This practice applies to sites where:

1. The topography is generally irregular,
2. Waterway and/or gully erosion is a problem,
3. Sheet and rill erosion is controlled by other conservation practices,
4. Runoff and sediment has damaged land and improvements,
5. Soil and site conditions are suitable, and,
6. Adequate outlets are available or can be provided.

This practice is not applicable to waterways where construction of the basin would destroy important woody wildlife cover and the present watercourse is capable of handling the concentrated runoff without serious erosion.

Water and sediment control basins are consistent with terrace intervals (see Table D-9). The drainage of each basin is designed to limit the duration of ponding, infiltration, or seepage so that the structure does not damage nearby crops. Where land ownership or physical conditions preclude treatment of the upper portion of a slope with terraces, a water and sediment control basin may be used to separate this area from, and permit treatment to the lower part of the slope. The uncontrolled drainage area to the basin used for this purpose should not exceed 30 acres.

The basins should be large enough to control the runoff from a 10-year, 24-hour-frequency storm without overtopping. The capacity of basins designed to provide flood protection or to function with other structures may be larger. Another storage volume design consideration is the anticipated accumulation of sediment, which could be estimated with the Universal Soil Loss Equation (USLE).

WASCOBs should be part of an overall system to protect soil and water resources. Practices such as terracing, contouring, conservation cropping, conservation tillage, and crop residue management should also be used to control erosion.

Water and sediment control basins shall not be used in place of terraces. When a ridge and channel extend beyond the detention basin or level embankment, terraces are appropriate.

This BMP may reduce the volume and rate of discharge. When underground outlets are used, infiltration through the catchment will increase and runoff will be decreased. Peak flows will be reduced by temporary storage. Where snow is present, it is trapped in the channels and catchments of the BMP and infiltrates into the soil. This BMP traps and removes sediment-attached pollutants from runoff. Trap efficiencies for sediment and total phosphorus may exceed 90 percent in Indiana's silt loam soils. Dissolved substances, such as nitrates, may also be removed from discharge from downstream areas with increased infiltration.

7. RESIDUE MANAGEMENT

There are several agricultural BMPs that increase the plant residue in soils and reduce erosion. Among these are no-till/strip till, mulch till, ridge till, and seasonal residue management. Each of these BMPs is instrumental in conserving soil moisture, increasing soil infiltration, reducing soil loss, and improving soil tilth.

The NRCS defines no-till/strip till as managing the amount, orientation and distribution of crop and other plant residues on the soil surface year round, while growing crops in narrow slots, or tilled or residue free strips in soil previously untilled by full-width inversion implements. This practice applies to all cropland and other land where crops are grown. Combines or similar machines used for harvesting are equipped with spreaders that distribute plant residue over the fields so that residues are retained on the field. Post-harvest grazing should not be allowed.

Planters are equipped to plant directly through untilled residue or in a tilled seedbed prepared in a narrow strip along each row. Although not universal, no-till planting generally relies on an increased use of herbicides to control weeks, but greatly reduces soil loss from the fields. No till or strip till can be practiced continuously or may be part of a system which includes other tillage and planting methods such as mulch till.

The mulch till practice is similar, and defined by NRCS as managing the amount of crop and other plant residues on the soil surface year round while growing crops where the field surface is tilled prior to planting. This BMP applies to all crop land and applies to tillage for both annual and perennial crops. Tillage implements are equipped to operate through plant residues without clogging and to maintain residue on or near the soil surface by undercutting or mixing. Planters, drills, or air seeders plant in residue on the soil surface or mixed in the tillage layer.

Ridge till is manages the amount of crop residues on the soil surface year-round, while growing crops on preformed ridges alternated with furrows protected by crop residue. Following harvest, residues are left until planting with no additional disturbance except for normal weathering. Ridge height is maintained throughout the harvest and winter seasons by controlling equipment or livestock traffic. After planting, residues are maintained in the furrows until the ridges are rebuilt by cultivation. Ridges are rebuilt to their original height and shape during the last row cultivation. Loose plant residues are retained on the field and uniformly distributed on the soil surface. Cultivation and planting equipment designed to operate on ridges is used, such as cultivators equipped with ridging attachments, and planters equipped with ridge planting attachments such as row cleaning devices and guidance systems. Planting and fertilizer placement shall disturb no more than one third of the row width. Soil and residue removed from the top of the ridge shall be moved into the furrow between the ridges. After planting, the top of the ridge is at least three inches higher than the furrow between the ridges.

Seasonal residue management involves using plant residues to protect cultivated fields during critical erosion periods. Wherever possible, the farmer should leave stubble standing over winter to prevent soil erosion and to trap snow. The management of crop residue is based on the amount of residue produced by the crop. When relatively small amounts of residues are available other practices will have to be used to maintain the necessary residue cover. This may include limiting grazing of the crop residues and not baling the cover.

8. STRIPCROPPING

Contour stripcropping is the growing of crops in a systematic arrangement of strips or bands on the hillside contour to reduce water erosion. The crops are arranged so that a filter strip of grass or close-growing crop is alternated with a strip of clean-tilled crop or fallow; or a strip of grass is alternated with a close-growing crop. Contour stripcropping is applicable to sloping cropland and on certain recreation and wildlife land where the topography is uniform enough to permit tilling and harvesting, and where it is an essential part of a cropping system to effectively reduce soil and water losses.

Contour strips should outlet into a stable outlet such as a waterway, water and sediment control basin, field border or other nonerosive areas and not outlet into end rows where excessive erosion down the slope might be accelerated. Contour strips are established with consideration given to the field and machinery conditions with up to 10 percent deviation of strip widths permissible (Table D-6).

Table D-6

CONTOUR STRIP WIDTHS

(Source: NRCS Conservation Standards)

Slope	P Values[1/]			Maximum Strip Width[2/]	Maximum Slope Length[3/]
(%)	A	B	C	(feet)	(feet)
1 to 2	0.30	0.45	0.60	130	800
3 to 5	0.25	0.38	0.50	100	600
6 to 8	0.25	0.38	0.50	100	400
9 to 12	0.30	0.45	0.60	80	240
13 to 16	0.35	0.52	0.70	80	160

1/ P Values:

A – For 4-year rotation of row crop, small grain with meadow seeding, and 2 years of meadow.

B – For 4-year rotation of 2 years row crop, winter small grain with meadow seeding, and 1-year meadow.

C – For alternate strips of row crop and winter small grain.

2/ Adjust strip width limit, generally downward, to accommodate widths of farm equipment.

3/ Maximum length may be increased by 10 percent if residue cover after crop planting will regularly exceed 50 percent.

Field stripcropping is similar to contour stripcropping. Field stripcropping is the growing of crops in a systematic arrangement of strips or bands across the general slope, not on the contour, to reduce water erosion. The crops are arranged so that a strip of grass or close-growing crop is alternated with a clean-tilled crop or fallow. It is applicable for controlling erosion and runoff on sloping cropland where contour stripcropping is not practical. Strips are laid out across the slope as nearly on the contour as practicable. No two adjoining strips will be in clean-tilled crops or fallow. As with contour stripcropping, grassed waterways, water and sediment control structures, terraces or diversions should be established and maintained where concentrated water flow would otherwise cause gully erosion. The widths of strips are defined below. A deviation of 20% in width is acceptable.

Table D-7

FIELD STRIPCROPPING STRIP WIDTHS

(Source: NRCS Conservation Standards)

Percent Slope	Strip Width (feet)
1 – 2	130
3 – 8	100
9 – 16	80

Both field and contour stripcropping affect the water budget, especially volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation and ground water recharge. These BMPs also have filtering effects on water quality because the strip vegetation and reduces movement of sediment and dissolved and sediment-attached substances.

9. TERRACING

A terrace is an earth embankment, channel, or a combination ridge and channel constructed across the slope to reduces slope length, erosion, and sediment content in runoff water. It is a broadly practiced BMP wherever water erosion is a problem, there is a need to conserve water, and the soils and topography are such that terraces can be reasonably constructed and farmed.

As with stripcropping, terrace spacing is usually determined by the Universal Soil Loss Equation (USLE). The spacing shall not exceed the slope length determined by using the allowable soil loss, the most intensive use planned, the expected level of management, and the terrace P factor (Table D-8).

Table D-8

TERRACE P FACTORS

(Source: NRCS Conservation Standards)

Horizontal Interval	Closed Outlets[1]	Open outlets, with percent grade [2]		
(feet)		0.1–0.3	>0.3-0.7	>0.7
<110	0.5	0.6	0.7	1.0
110 - <140	0.6	0.7	0.8	1.0
140 - <180	0.7	0.8	0.9	1.0
180 - <225	0.8	0.8	0.9	1.0
225 – 300	0.9	0.9	1.0	1.0
>300	1.0	1.0	1.0	1.0

NOTES:

If contouring or stripcropping P factors are appropriate, they can be multiplied by the terrace P factor for the composite P factor.

1/ "P" factor for closed outlet terraces also apply to terraces with underground outlets and to level terraces with open outlets.

2/ The channel grade is measured on the 300 ft of terrace or the one-third of total terrace length closest to the outlet, whichever is less.

The maximum horizontal interval between terraces should not exceed the distances tabulated below for the conditions shown.

Table D-9

MAXIMUM HORIZONTAL INTERVAL FOR TERRACES

(Source: NRCS Conservation Standards)

Slope	**USLE – R Factors**		**With Contour Stripcropping**
	35 to 175	>175	
(%)	(ft)	(ft)	(ft)
0 – 2	500	450	600
2.1 – 4	400	300	600
4.1 – 6	400	200	600
6.1 – 9	300	150	400
9.1 – 12	250	150	250
12.1 – 18	200	150	150
18.1 – up	200	150	150
Minimum spacing required, all slopes	150	90	90

The maximum limits should not be exceeded when making adjustments as indicated below. Spacing may be increased as much as 10% to provide better alignment or location, to adjust for farm machinery, or to reach a satisfactory outlet. Spacing may be increased an additional 10% for terraces with underground outlets. For level terraces used for erosion control and water conservation, the spacing is determined as indicated above, but the maximum horizontal spacing should never exceed 600 ft. Additionally the terrace shall have enough capacity to control the runoff from a 10-year frequency, 24-hour storm without overtopping. Other design criteria are available from the NRCS.

Terraces should be part of the treatment system to protect soil and water resources. In addition, practices such as contouring, a conservation cropping system, conservation tillage, and crop residue management shall also be used to control erosion. Terraces should not be used in place of water and sediment control basins. The planned management system should reduce soil loss in the terrace interval to prevent excess maintenance and operation problems.

Storage terraces retain runoff, increase infiltration, and conserve soil moisture. Gradient terraces may cause a slight increase to a significant decrease in surface runoff depending on field topography and terrace channel grade. This BMP reduces slope length and the amount of surface runoff which passes over the area downslope from the structure. The erosion rate and production of sediment within the terrace interval will be reduced. Terraces trap sediment and reduce the sediment and associated pollutant content in the runoff water.

Terraces intercept and conduct surface runoff at a nonerosive velocity to stable outlets, thereby reducing gully erosion. Trap efficiencies for sediment and total phosphorus may exceed 90 percent for terraces with underground outlets in Indiana's silt loam soils. Underground outlets may collect soluble nutrient and pesticide leachates and convey them directly to surface waters. In this way, by collecting surface runoff and conveying it directly to a receiving stream, terraces may increase the delivery of pollutants to surface waters. Terraces may have a detrimental effect on water quality if they concentrate and accelerate delivery of dissolved or suspended nutrient or pesticide pollutants to surface or ground waters.

10. NUTRIENT MANAGEMENT

Proper nutrient management economizes the natural process of nutrient cycling to optimize crop growth and minimize environmental losses. According to NRCS (1999), the practice of nutrient management serves four major functions:

1. Supplies essential nutrients to plants for adequate production,
2. Provides for efficient and effective use of scarce nutrient resources,
3. Minimizes environmental degradation caused by excess nutrients in the environment, and,
4. Helps maintain or improve the physical, chemical, and biological condition of the soil.

Modern agricultural production depends on an adequate supply of nutrients being available to the crops. The agricultural yield increases during the last 50 years can be, in part, attributed to high levels of crop nutrition that support high yielding crop varieties. Unfortunately increased use of nutrients has, and continues to, damage the environment. Excess nutrients produce nuisance vegetation including algae, which diminish the economic, social and environmental benefits of aquatic and terrestrial habitats.

The objective of nutrient management is to supply adequate chemical elements to the soil and plants without creating an imbalance in the ecosystem. Protecting the environment requires controlling both the source of nutrients and their fate and transport from those sources. Nutrient management assessment tools available include tools to assess the agronomic needs of a crop and tools to assess environmental risk associated with nutrient applications. Agronomic needs assessment tools include:

- Traditional soil tests, providing an important baseline of information, should be performed every 3 to 5 years, or more often if conditions change.
- Plant tests provide information on the nutrient status of the crop, and can determine the success of the current nutrient management plan in meeting crop needs.
- Organic materials analysis, where manure or municipal sewage sludge are applied to fields, should include moisture content. These data are necessary to develop an accurate nutrient budget.

Environmental risk assessment tools provide information on the fate, transport and potential environmental risk associated with nutrient applications. These tools may identify sensitive areas where nutrient management is critical to protect a water resource. A few of the less complex risk assessment tools include:

- The leaching index (LI) assesses the intrinsic probability of leaching occurring if nutrients are present and available to leach. LI is a simple index of potential leaching based on average annual percolation and seasonal rainfall distribution.

- The Universal Soil Loss Equation (USLE) assesses the potential for soil and adsorbed nutrient loss through water erosion.
- The Water Quality Indicators Guide (WQIG) is a qualitative tool for assessing surface water quality impacts from five major sources of agriculturally related nonpoint source pollution: sediment, nutrients, animal waste, pesticides, and salts.
- The Nitrate Leaching and Economic Analysis Package (NLEAP) is a moderately complex, field scale model that assesses the potential for nitrate leaching under agricultural fields. NLEAP can be a powerful tool to assess nutrient management planning decisions.
- The phosphorus index (PI) is a simple assessment tool that examines the potential risk of P movement to streams and lakes based on various landforms and management practices.
- The 303(d) list can often be used to help assess the potential environmental risk associated with a particular land area. Indiana's 303(d) report is available at www. This report lists waterbodies designated as impaired for one or more of its designated uses.
- Water quality monitoring can be used to assess the potential impairment of waterbodies and associated environmental risk. Long-term monitoring, such as monitoring performed by the IDEM and U.S. Geological Survey can show quantitative trends in water quality over time.
- A variety of water quality models, including AGNPS, WATERSHED, ANAGNPS, SWRRB, and SWAT, may be used to look at the influence of different management scenarios and environmental conditions on the potential environmental risk of nutrient contamination to waterbodies.

A nutrient management plan is a farm's guide for making decisions on the placement, rate, timing, form, and method of nutrient application. They help producers become fully aware of the steps that need to be taken to successfully manage their nutrients and protect natural resources. Components of a nutrient management plan are listed in the adjacent text box. These elements are all-inclusive, but are guidelines for the minimum requirements for a nutrient management plan.

There are abundant references on nutrient conservation practices for pollution control and reduction. Many of the available techniques are related to soil erosion control. Nutrient control techniques generally fall into one or more of the following categories:

- Source reduction
- Reduction of nutrient availability
- Reduction of soil particle detachment
- Reduction of dissolved and suspended nutrient transport

Nutrient Management Plan Components

1. Aerial photographs or maps
2. Sensitive resource areas and nutrient restriction areas
3. Results of soil, plant and organic materials analyses
4. Crop sequence and rotation plan
5. Expected crop yields
6. Quantification of nutrient sources
7. Crop nutrient budget
8. Recommended rates, timing and methods of application
9. Operation and maintenance

REFERENCES

Fields, S. 1993. Regulations and Policies Relating to the Use of Wetlands for Nonpoint Source Pollution Control. Pages 151-158 in Created and Natural Wetlands for Controlling Nonpoint Source Pollution, R.K. Olson (ed.), CRC Press, Boca Raton, FL.

Natural Resources Conservation Service (NRCS). 1999. CORE4 Conservation Practices Training Guide. The Common Sense Approach to Natural Resource Conservation. USDA NRCS, August, 1999.

Schueler, T.R., 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Publication no. 87703. Metropolitan Washington Council of Governments. 275pp.

Schueler, T.R. P.A. Kumble, and M.A. Heraty. 1992. A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution In the Coastal Zone. Publication no. 92705. Metropolitan Washington Council of Governments. Washington, DC. 127pp.

US Environmental Protection Agency. 1988. Design Manual: Constructed Wetlands and Aquatic Plant Systems for Municipal Wastewater Treatment. EPA/625/1-88/022. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC. 83pp.

Water Environment Federation (WEF) and American Society of Civil Engineers (ASCE). 1998. Urban Runoff Quality Management. WEF, Alexandria, Virginia.